MACHINERY.

April, 1908.

ARMOR-PLATE FORGING AND MACHINING AT THE BETHLEHEM STEEL WORKS.

WHILE collecting material for the article published in the November, 1907, issue of MACHINERY, describing the armor-plate vault built by the Bethlehem Steel Co., the writer had the opportunity to see something of the forging and machining operations on armor-plate as carried on at this plant. These operations are so impressive that it has seemed worth while to speak of them briefly here. This description, especially so far as it relates to the forging, is necessarily non-technical, since this work is somewhat outside the range of the writer's practical experience.

So far as the spectacular features of the forging shop are concerned, the interest centers about the 16,000-ton hydraulic forging press, shown in Figs. 1 and 2. Beneath this press the ingots, as they are received from the casting pit, are worked to the proper dimensions for the finished plate into which they are to be formed and machined. With its attendant furnaces, hydraulic pumping engine, cranes and other handling apparatus, this machine forms a large share of the equipment of the department.

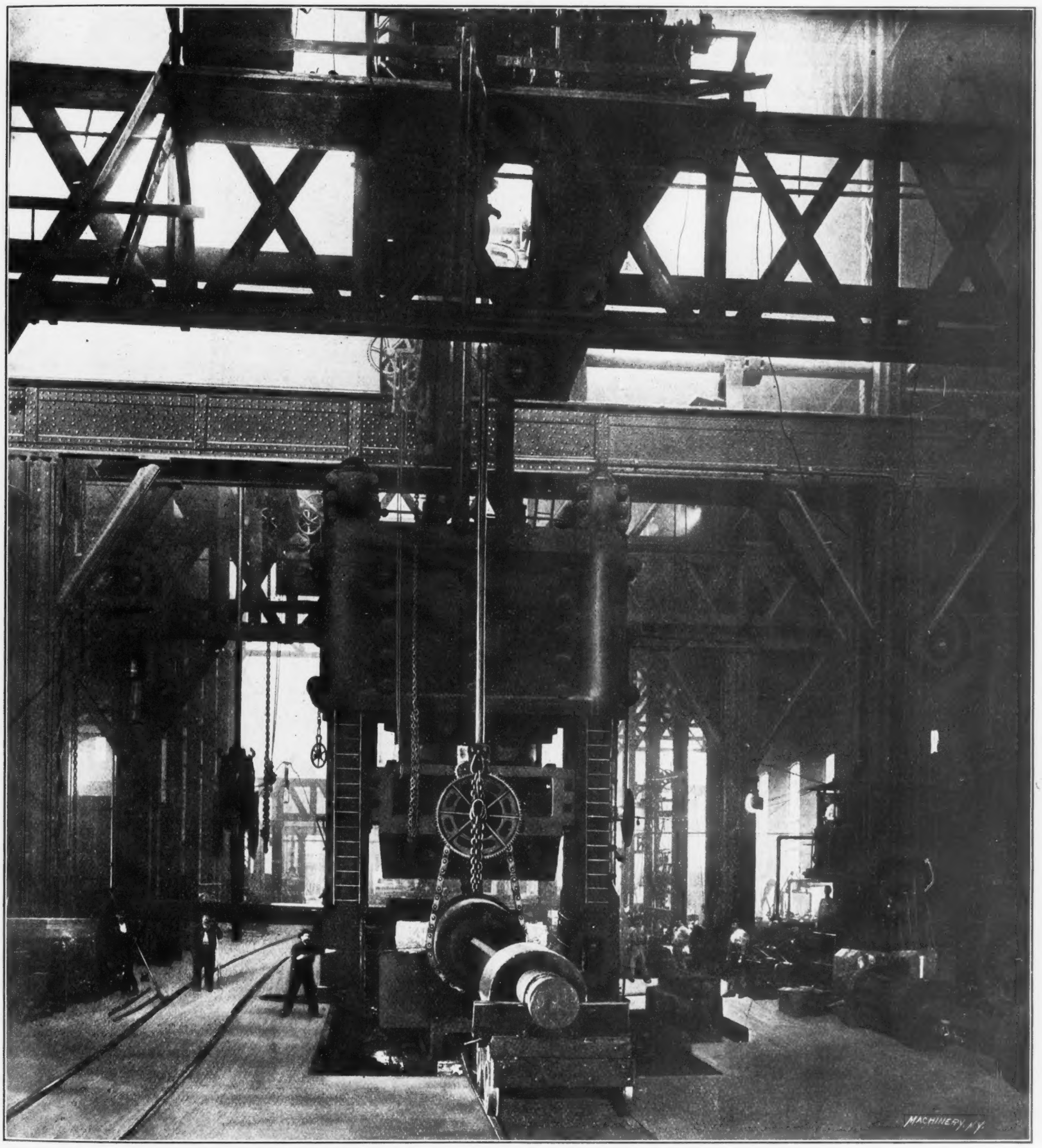


Fig. 1. An Ingot being worked to Shape beneath the 16,000-ton Press of the Bethlehem Steel Co.

The impressive thing in the forging is the handling of the great slabs of hot metal, entirely by mechanical means. It might, in fact, obviously be said of an armor-plate forging, as of a shredded wheat biscuit, that it arrives at its completed form "without the touch of human hands." As the observer

stands on the floor of the shop, gazing curiously at the huge machine and its numerous human attendants standing idly by it, a blast of heat strikes him in the face and he starts back, noting for the first time that the front of the furnace on his left is being slowly raised, revealing the glowing interior. Next, seemingly of its own volition, a car whose body forms the floor of the furnace, deliberately advances, bringing with it, on a pile of incandescent fire-brick, the ingot which has been soaking in the furnace, preparing for the forging operation.

As the ingot advances, we now have an opportunity to admire the dexterity of the crane operator. The geared reel seen depending from the crane trolley in Fig. 1, is provided for this operation with a pair of hooks, attached to opposite ends of a flat link chain arranged somewhat as shown in Fig. 3, one of the hooks being lower than the other. The ingot is so mounted on the fire-brick that its ends project. The crane operator catches one of the hooks centrally under the end of the mass of metal as shown, and then brings the reel over until the other hook is engaged. He now raises it clear from the car (which retreats to the furnace, closing the door behind it), swings it about at right angles, and deposits it on one of the die-blocks in front of the press, with its squared stem or riser pointing toward us.

The crane operator has now to attach to the hot ingot what, in default of a better name, we may describe as the "handle" by which it is manipulated. This consists of a great beam whose rear end rests on the truck seen in the foreground of Fig. 1, and whose front end carries a socket with an aperture fitting the stem of the ingot. An endless chain is passed around the reel which hangs from the crane, and the socket is hung in this. Having been adjusted to the proper height by the crane operator, it is advanced toward the ingot and pushed into place over the riser. The crane operator now raises the reel, and with it the socket and ingot, and the bed on which it rested is moved back out of the way. The outer end of the "handle" is weighted (in Fig. 1 a heavy ring is used, as shown) so that the work may not over-balance the end of the beam which rests on the truck. The crane man, by the mechanism at his command, now has complete control of the mass of hot metal. He may raise it and lower it, turn it over (by revolving the reel), advance it toward the press or away from it (by operating the crane trolley, which is followed by the truck) or swing the whole from side to side about the centers of the truck as a pivot.

On the other side of the press this apparatus is duplicated, so that if the riser has been sheared off beneath the press, the ingot may be worked from end to end, being passed through by the front holder until it is half-way done, when the one in the rear grasps it and draws it through, returning it again, and passing and repassing it until the work is completed. After the riser has been removed, the plate is held by simple solid jaws at the end of the beams, in place of the sockets shown. These movements are all hydraulically controlled, the pressure for the crane movements being delivered to the bridge and the traveler by "scissors pipes"—jointed pipes which open and close to accommodate the movements of the members to which they are connected. The die-blocks beneath the bed are also hydraulically operated, being brought into place or moved to one side and changed one to another as occasion may require. The men who operate the valves controlling these various movements as well as those of the press itself and of the furnace, are stationed at the right of Fig. 1.

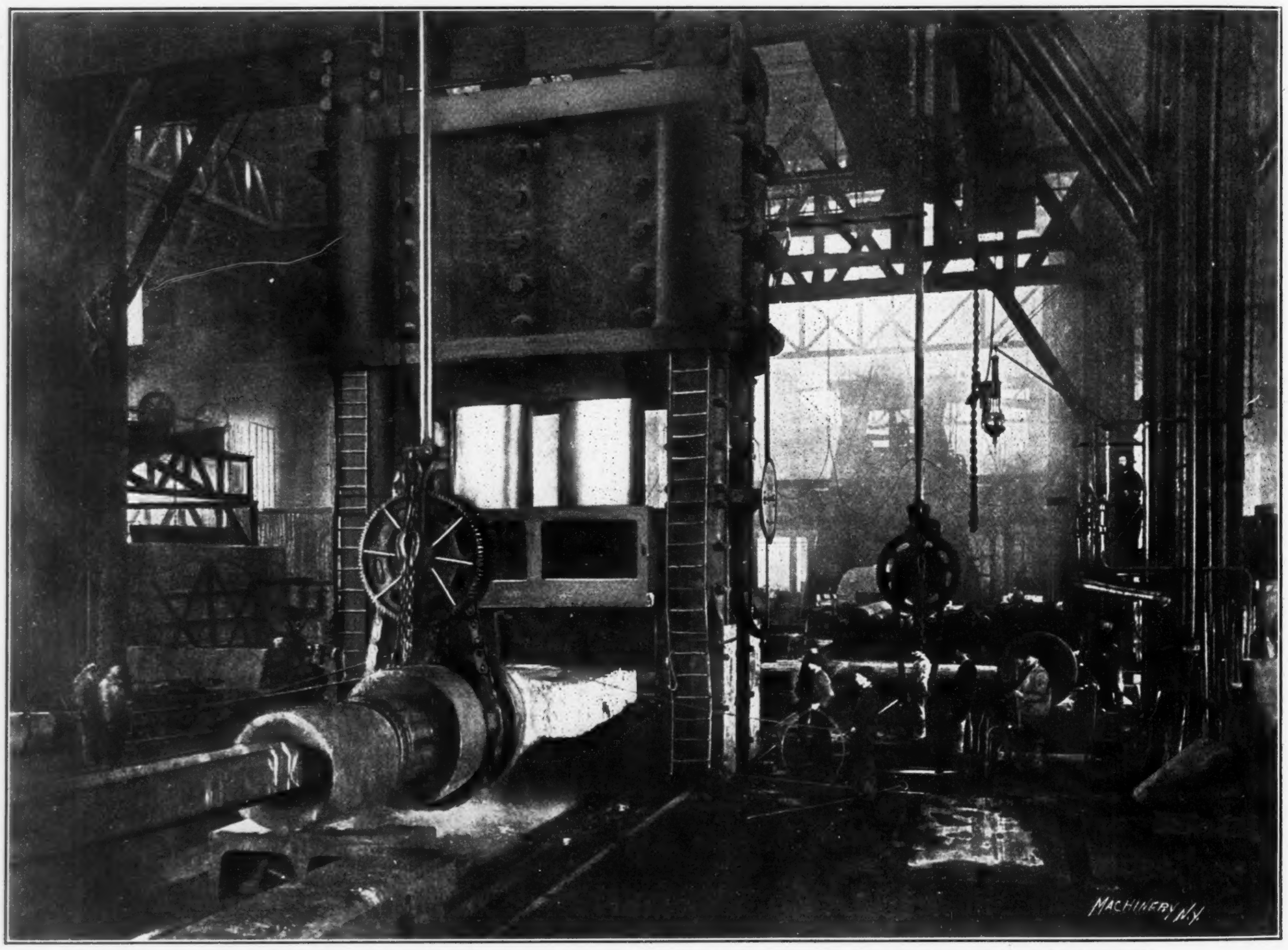


Fig. 2. The Forging Press with the Ram Lowered on the Work. Note the Discarded Steam Hammer in the Background.

As is well known, the operation of forging by pressure is quite different from forging under the hammer. Instead of pounding the ingot into the shape desired, the end of it is placed between the comparatively narrow dies and given what is apparently a gentle squeeze. The plungers are raised again, the ingot advances another step, and a second squeeze is given. This action is continued progressively until the entire area it is desired to flatten out has been passed over. This successive squeezing is then repeated until the metal has been worked into a plate of the required dimensions. The edges of the plate, when worked by this process, show the characteristic bulging edges resulting from pressure forg-

ing. This shows very plainly that the working of the metal extends clear through to its center, forcing it outward. As most of our readers are aware, it is the ability of the hydraulic press to thus thoroughly work the metal that has caused it to supersede the old-fashioned steam hammer treatment, which, on large work, does little more than deform the surface of the metal, the suddenness of the impact preventing

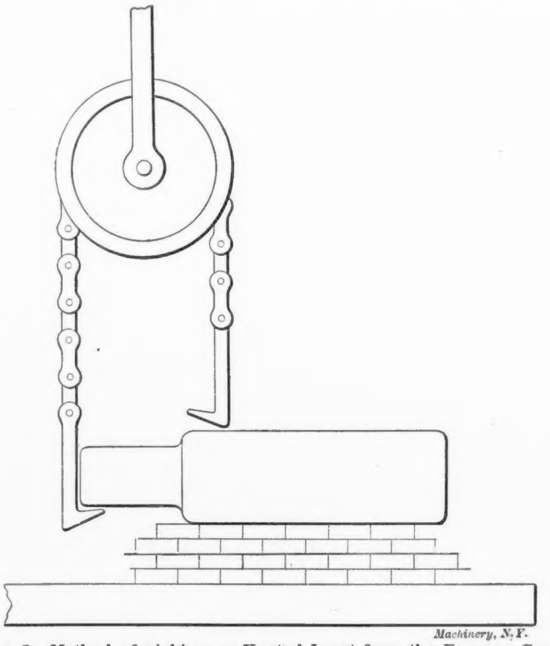


Fig. 3. Method of picking up Heated Ingot from the Furnace Car.

the transmission of the action throughout the whole body. The 125-ton steam hammer, of which a model was shown at the Columbian Exposition in 1893 and which was superseded by this press, may be seen dimly in the background of Fig. 2.

During the forging operation, the work performed on the mass serves to some extent to replenish the heat lost through radiation, so that it is nearly as hot at the conclusion of the

connected with the upper die block by ball and socket joints, and they may be operated independently, so that by using suitable upper and lower dies the plate may be pressed to any desired form.

The metal used for armor-plating, particularly that which is to be hardened by the Krupp process, being of a material which is very tough, even in its softest condition, requires tools and machines for finishing which have unusually strong construction. An idea of their massiveness may be obtained by referring to Fig. 4, which shows a double head milling machine, driven by direct-connected steam engines. This tool is at work finishing the edges of a pair of armor-plate forgings, one on either side. These heads are about 8½ feet in diameter, the cutting circle being 88 inches in diameter, with 42 cutters in each head. A pile of the massive cutters used is shown on the floor in the foreground, at the back and at the left of the small electric motor and controller shown on the floor. The stock used for them is 6 inches by 3½ inches in section. Each table is 8 feet wide by about 23 feet long and has a transverse feed of 21 feet. The double engines have cylinders each 10 inches diameter by 14 inches stroke. The heads revolve very slowly, apparently not giving a surface speed much over 20 feet per minute, or thereabouts. The chips taken are so heavy, however, that it is possible to advance a cut 2 inches deep on an armor-plate 12 inches thick, at the rate of 40 inches per hour.

After machining, the plates are given their heat treatment, being either Harveyized or hardened by the Krupp process. The former is a case-hardening operation pure and simple, though carried to a great depth, and involving weeks of time. The Krupp process is the Harvey process, plus a treatment of which the details are secret. This gives to the metal a peculiar tough fibrous structure which forms an almost unbreakable support for the hardened face of the plate. This hardened face may be chipped and cracked by the impact of the projectile, but the tough backing will hold the plate together without fracture.

In operation, the Krupp process is said to be a very delicate and uncertain one. Two pieces of identical shape may

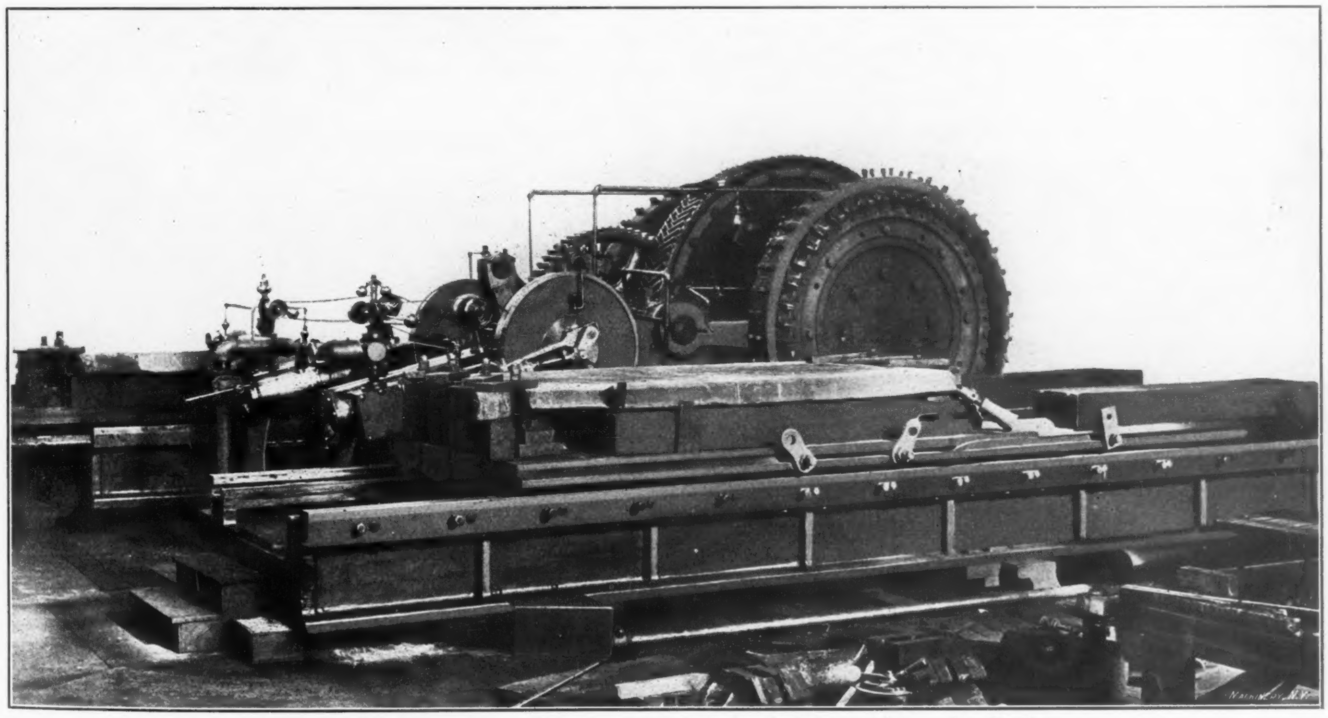


Fig. 4. Double, Steam-driven Rotary Planer, for Finishing the Edges of Armor-plate Sections.

working as at the beginning. A noticeable feature of the forging is the shelling off of huge scales of oxidized steel from the surface of the metal, as the operation proceeds.

After the forging, if the plate has to be curved to fit the lines of the ship it is to be applied to, or has to be bent to cylindrical shape for forming a gun turret, it is again heated and shaped under a forming press, similar in design to the forging press shown in Figs. 1 and 2, but of somewhat smaller capacity. In this machine, however, the two plungers are

be treated together and laid aside to cool after the treatment is finished. So far as can then be determined, they are in the same condition and have had the same care in every respect. But one of them will have the metal of which it is composed hardened to a very high degree on the face, this merging into a tough fibrous structure with fibers running from front to back as though the plate were sawed across the grain from the end of a huge wooden beam. The other, capriciously and without warning, will crack in two when it

has almost cooled to a point where it can be touched by hand, and the fracture will show a coarse crystalline structure absolutely useless for resisting the impact it may be called upon to stand. Something like 30 per cent of all the finished pieces of armor-plate treated by the Krupp process are spoiled in this way—apparently unavoidably. It is this large percentage of scrap, so the writer was told, which acounts for the high cost of making Krupp armor-plate.

After the heat treatment, the perfect plates again go to a forming press to be straightened, so that their finished surfaces are again squared and in line with each other. This is done by heating them gently, and bending them under the forming press previously described.

Though of huge size, the hydraulic forging press is of such simple construction that its tremendous power is not at first realizable. A walk to the upper end of the shop, however, where is located the 15,000-horse-power hydraulic pump which serves the press, gives the imagination data to work on in appreciating the tremendous amount of work expended in forming the hot ingot into a plate of the desired dimensions. This pump, which was built at the plant, was designed by the well-known engineer, E. D. Leavitt, of Cambridge, Mass. This engine and the press, as well, have been previously described in MACHINERY (see the issue of October, 1899).

* * *

DEFECTS IN THREADS FOR STEAM-TIGHT JOINTS.

In a recent issue of the *Valve World* attention is called to the fact that defects in the tapered thread of the joints of wrought iron and steel pipe are not of so great consequence in obtaining a tight joint as is ordinarily assumed. The Crane Co., of Chicago, has endeavored to show that the ideas held regarding the placing of too much importance on defects in the threads of pipe and fittings, are erroneous, and this company has made some conclusive tests on this subject. The results of these tests seem to give evidence that the many small defects for which pipe and fittings are often rejected, are entirely unimportant in regard to the efficiency of the threaded joints for making a tight connection. One of the common causes assigned for the rejection of pipe is that threads are a trifle broken. To prove of how little consequence this is, a piece of 8-inch pipe was threaded for a distance of 2¼ inches. This pipe was then put in a lathe and the thread was mutilated by turning three circular grooves, each 3/16 of an inch wide, on the surface of the pipe, thereby cutting away some of the threads entirely, and leaving only fragments of some of the other threads. The tops of the remaining threads were then turned off, so that they had a flat surface on the top 1/32 inch wide. At three places on the circumference of the tapered thread flat spots were then filed, one inch wide and two inches long. Twenty-five grooves were then filed in the thread of the pipe, and the same number in the coupling, all perpendicular to the direction of the thread, and two-thirds of the depth of the thread. When this deliberate mutilation was finished, the threads were cleaned, and were thoroughly coated with a cement for making a tight joint, in this case, "Crane" cement. The joint was then screwed up so that the lengthwise grooves did not come opposite each other. The outer ends of the pipe and the coupling were then plugged and the joint was tested to 425 pounds air pressure. The joint was found to be tight, and the same result followed a hydraulic pressure test of 1,000 pounds per square inch. This test also indicates of how little importance it really is in taper-threaded fits if the taper of the two components making the joint should not be exactly the same. In fact, in many cases, pipes are not threaded with the same taper on the outside as the taper of the tap used for threading the corresponding fitting on the inside, but nevertheless, a steam or water-tight joint is effected, by screwing the component parts tightly into one another, and using some suitable compound to make a tight joint.

* * *

A lathe shear is a poor anvil.
The squeak of the dry bearing goes round the world.
A crack in the floor is a poor straightedge.

THE PROBLEM OF THE SPIRAL CONVEYOR.

LAYING OUT THE FLIGHTS.

F. WEBSTER.

In making steel spiral conveyors of small sizes, the pattern for the flights is laid out and the disks are punched from sheet metal. Some makers use the following method for laying out the pattern:

Suppose the conveyor is to be 12 inches outside diameter, and is to have a pitch of 12 inches, as shown in Fig. 1, and that 2-, 2½-, and 3-inch pipes are to be used for the shafts of three sizes. The length of the helix on the outside of the shaft in each case is found by the triangle method; that is, the length equals that of the hypotenuse *a d* of a triangle,

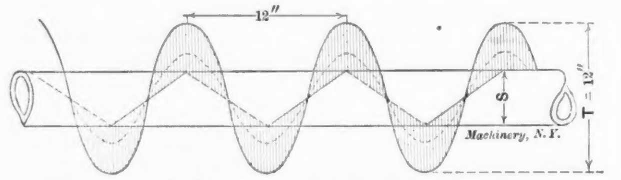


Fig. 1. Typical Spiral Conveyor, showing Pitch, Diameter, etc.

Fig. 2, having an altitude *a c* equal to the pitch, and the base *c d* equal to the circumference of the shaft. Thus, in the case of a 2-inch pipe which has an outside diameter of 2.375 inches, the length of the helix on the pipe equals $\sqrt{12^2 + (2.375 \times \pi)^2} = 14.13$ inches, and this divided by π (3.1416) gives 4½ inches as the diameter *d*, Fig. 3, for the circumference of the hole in the disk for the flight. For the 2½-inch shaft, the diameter for the hole in the disk is found to be 4 25/32 inches, and for the 3-inch shaft, it is 5 3/16 inches. The outside diameter *D* of the disk is found by adding the diameter *d* of the hole to the difference between the diameter *T*, Fig. 1, of the conveyor, and the outside diameter *S* of the pipe. For the 2-inch pipe, the outside diameter *D* of the disk equals 14⅛ inches; for the 2½-inch pipe, 13 29/32 inches; and for the 3-inch pipe, 13 11/16 inches. When the disks are punched, they are also cut along a radial line *E*, so that one end of the flight can be raised above the other. From a comparison of the values found for the outside diameter of the disk, it will be seen that the outside diameter becomes less as the size of the shaft increases, notwithstanding the fact that the diameter of the finished conveyor remains fixed at 12 inches. Hence, the inquiry arises, is this correct, and also is the method described above the correct one for laying out the pattern?

It is true that the outside diameter of the disks for the flights will be less for the large shaft than for the smaller ones, but this method of laying out the patterns will not

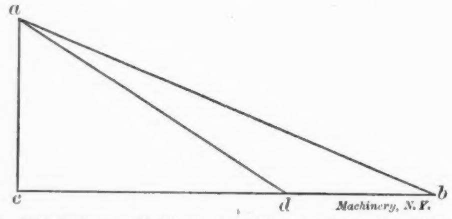


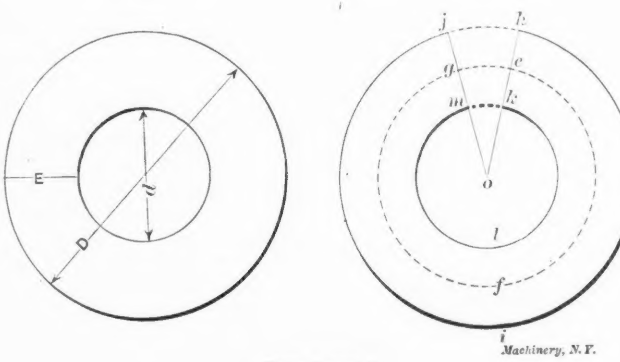
Fig. 2. The Triangle Method of finding the Length of the Spiral.

give the correct dimensions for either the inside or the outside diameters, as will be shown by the following discussion.

In the first place, it must be understood that the flight of a conveyor forms a warped surface, and this cannot be made directly from a flat surface without the material being bent and stretched, or *raised*, as it is called, in order to get the flight set square with the shaft and prevent buckling. The following method will give dimensions more nearly correct for the disk so that after the disk has been raised it will approximately fit both the helix on the pipe and the outside helix of the conveyor. The method consists in constructing a helix, shown by the dotted curve in Figs. 1 and 4, on the flight midway between the outside of the shaft and the edge of the conveyor. The length, *a b*, Fig. 2, of this helix is then determined by means of a right-angled triangle in the usual way. The length *a b* of the hypotenuse of the triangle is not

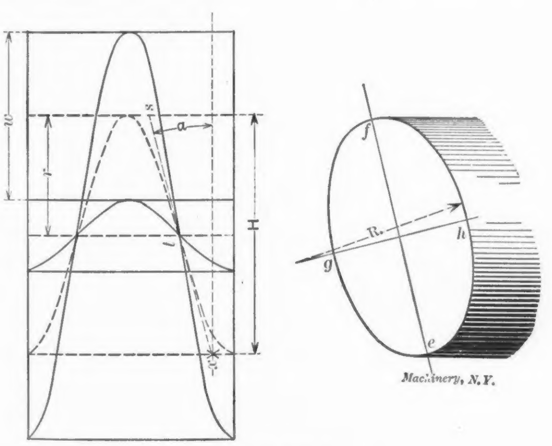
used, however, for the circumference of a circle, as was done in the first method explained, but an entirely different principle must be used for the remainder of the construction. This principle will be most easily understood by considering a more simple example than that of a conveyor flight, namely: the pattern for the surface of the frustum of a cone, shown in Fig. 5. The method requires the use of a slant height *O C* of the cone as a radius, drawing an arc *A* from the base, and an arc *B* from the top, and on these arcs laying off lengths equal to the circumference of the base and the top, respectively. The developed surface *K L M N* is then the required pattern.

Applying the principle just explained to the construction of the flight of a conveyor, the layout may be made to approach the theoretical requirements as follows: Pass a plane through the tangent *x s*, Fig. 4, to the middle helix and perpendicular to the axis of the cylinder. The section formed will be an ellipse, as shown in Fig. 6, having its long axis *e f* equal to the tangent *x s*, Fig. 4, and its short axis *g h* equal to the diameter *H* of the cylinder. The radius of curva-



Figs. 3 and 7.

ture of the helix at the point *t*, Fig. 4, of tangency is practically the same as that of the flat side of the ellipse at the same point *h*, Fig. 6. To develop the curve on a plane surface requires the use of the radius of curvature of the helix for drawing the arc (in the case of the frustum of a cone given above, the slant height of the cone was used for the radius). The length of the radius of curvature *R*, Fig. 6, of a helix or ellipse equals $\frac{r}{\cos^2 a}$, where *r* equals the radius of the cylinder, and *a* is the angle of the helix as shown in Fig. 4.



Figs. 4 and 6.

This formula is derived by the use of analytical geometry, and will not be explained here. The length of the radius of curvature can also be found graphically.

When the radius of curvature of the middle helix is found by using the formula, draw with it a circle *f*, as shown dotted in Fig. 7. On this circle lay off the length of the middle helix, as taken from the hypotenuse *a b* of the triangle Fig. 2, and draw lines from the center of the circle through the extremities *e* and *g* of the arc *e f g* representing the length of the helix. Lay off on each side of the central circle distances *e k* and *e h* equal to one-half the width *w*, Fig. 4, of the flight, and draw arcs *l* and *i* through them, thus completing the pattern *h k l m j i h* for the flight. An inspection of the figure shows that neither the diameter of the hole, nor that of the outside of the disk is the same as the values derived by calculation, according to the method first used. It will also be seen that the punching, Fig. 7, does not form a closed ring as

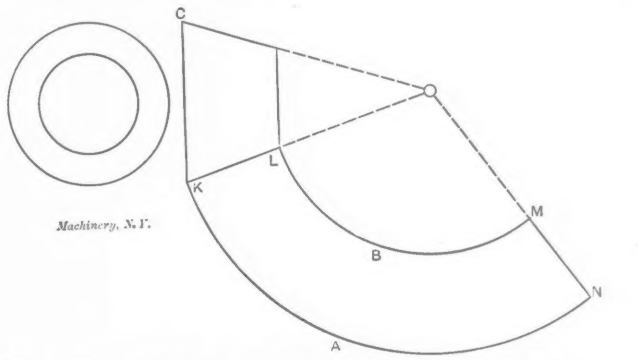


Fig. 5. Illustration of Method using Development of Cone Surface as Example of Method of finding Radius.

in Fig. 3, and hence, there will be more waste material in this case than where a closed ring is used for the pattern, but the work will be more accurate.

The reason for the outside diameter of the blank being smaller when a larger shaft is used, will be seen from a study of Figs. 4 and 6. If the diameter of the shaft be increased, the helix through the middle of the blade will be larger in diameter, and this will cause its tangent, *x s*, to have less slope. The plane through the tangent will then pass more nearly horizontal, and thus the ellipse cut from the cylinder will more nearly approximate a circle equal to the base of the cylinder. The radius of curvature of the helix then becomes shorter, or more nearly the length of the radius of the cylinder, and hence, the central circle in the layout will be less in diameter. This, in turn, decreases the outside diameter of the pattern.

* * *

CAN A BOY LEARN A TRADE IN A SCHOOL?

E. R. MARKHAM.*

The writer has read so many articles of late on this important subject that he concluded that a few ideas from him would not be amiss. The writer acknowledges that he is engaged in school work, and consequently would not be considered as competent to write from a practical man's point of view, but before he engaged in school work he had over 25 years practical machine shop experience, learned his trade, and worked as machinist and tool-maker for a number of years before taking charge of work himself, and while in charge of shops, the writer was instrumental in teaching the machinist's trade to more than one hundred young men. Having then been engaged in school work for seven years, he therefore feels himself in a position to speak with some understanding of the subject, and having also been connected with two manual training schools, in both of which evening classes for machinists and machine operators in machine shop work are carried on, he has become, in a measure at least, acquainted with the shortcomings of the present so-called apprenticeship system.

In the ordinary manual training school, as conducted at the present time, it is not possible to teach a boy a trade, neither is this attempted. What the school accomplishes, however, must be considered rather a surprise to a fair-minded man. For instance, a boy comes into the machine shop an hour and a half every other day, for a period of 80 weeks, five school days a week, this making a total of 300 hours, and from this should be deducted the time given to lectures and instructions along general lines. If the boy spent the whole 300 hours in the shop, the time for getting ready and cleaning his machine would have to be deducted, and, as he comes into a shop 200 times, this would aggregate a considerable amount to be deducted from the 300 hours. In a shop running 10 hours per day, six days a week, 300 hours would only make five weeks. Now, if the observer examines the range, quantity, and quality of the work done by the average

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pupil in the time mentioned, he must acknowledge that considerable progress has been made, and he will be convinced that a young man, under systematic training, will get along many times faster in a school than if placed in a shop under the conditions which now ordinarily prevail.

As previously stated, we do not attempt to teach trades to our pupils in the trade schools of to-day. However, we occasionally run across a boy who, although intelligent, shows no special fondness for academic work, or, in other words, book study; and such a boy may be given extra time in the shop and permitted to specialize in the shop. Such boys, when they enter into manufacturing work, and find employment in shops, generally give the best of satisfaction, and the schools many times receive word from manufacturers to send them all the young men of this type they can. It is apparent that many young men of this class cannot be furnished, and it is rarely the case that more than one or two at a time take this extra amount of shop work.

Instructors.

Any man, in order to be able to successfully teach any of the mechanical trades, must be a journeyman. He must have had a large all-around experience, and be able to explain to his pupils the various classes of work, as they present themselves. He must have a general knowledge of mechanics, and be able to give short lectures on the manufacture of iron and steel, shop methods, and explain desirability of certain metals for certain purposes. He must understand and also be able to impart to others, the most approved methods of doing work, and when having entered school work, must still try to keep in touch with the advancing achievements of machine shop work.

Outline Plan of an Efficient Trade School.

If trades are to be taught in schools, the mechanical departments must not be "the tail of the dog," as they sometimes are, and "bob-tails" at that. If a trade is to be taught, everything should be so arranged as to accomplish that end. The boy must be given sufficient time in the shop, so that it will be possible to give him the instruction necessary, and his studies must be selected so that he studies in particular those subjects which will help him in his shop work. Such subjects as are included under the head of mathematics, especially arithmetic, should be given special emphasis. The work in arithmetic should be made up of ordinary shop problems, and the use of various formulas entering into shop work. The problems in mechanics should be of a character that will help him in the shop, and apply to his every-day work. The drafting work should be of a kind that will render it easy for him to read working drawings, and he should be required to make drawings of the various details which he afterwards will be required to make in the shop. In this way, his drawing will not be a matter of copying, and the result aimed at will not be simply to get a neat drawing for the sake of getting a good, or passing, mark. The drawing becomes something more than a mere task to be performed. The pupil finds himself placing on paper something that he is to duplicate in wood or iron, and the matter of accuracy is more apparent to him, because if he makes a mistake in the figures, it may mean a great deal to him when he gets to working on the piece in the shop.

Objection to Trade Schools.

The main objection to the establishment of such courses, as have been outlined, in present schools is that it would entirely disarrange the established customs and programs of the school. This, however, would probably not be a bad thing. If a school is supposed to teach trades, everything ought to be shaped so as to give proper emphasis to the shop work. If the teaching of trades is attempted in the manual training high school, there will, of necessity, be a very sharp dividing line between the college course and the trade course. The training which will fit a boy to attend a college or some technical school must of necessity meet the requirements of such an institution, and very little time is left for shop work. Under the conditions existing in many schools, however, the amount of shop work given boys in the college and general courses is the same, and the boy who enters directly into practical work, when graduating, is no better equipped for his work than the boy who is to receive the education which will fit him for a more advanced engineering position. Therefore, if the time now spent in the study of subjects which will not be of direct benefit to the boy who intends to enter practical work directly from the school, were spent in acquiring specific trade education, the boy would be more directly benefited.

Commercial Basis of Trade Schools.

The argument is sometimes advanced that a school cannot be run on a commercial basis, and for this reason a trade cannot be taught along commercial lines. The writer does not know of any reason why a trade school could not be run on a basis at least *parallel* to that of a manufacturing establishment. The fact that such is not the case at present is no proof that it cannot be done. The difference might be that the boy familiar with arithmetic, as it should be taught to a boy learning a trade, would be given the proper speeds and feeds as a part of his trade, rather than to be told to "jack up the speed another cone," or "give her a little more feed," without being told what speed or feed is right for that particular job. In the shop, of course, a boy receives a large share of his instructions from the older men working with him, but whether it is wise or not depends altogether on the man instructing the boy, and on how much he knows, and how much he is willing to impart to the "kid."

If a real trade school is established, efficient journeymen should be employed about the shop. These men should be selected for their ability, character, etc., and being directly under the instructor, who should be a thoroughly practical man, would work according to his directions, so that the instruction which the pupils receive from observation of these men at work, will emphasize the instructions given directly by the instructor.

Then the question comes, what would one make in such a school? One could make some simple line of machinery, make all the jigs, fixtures and other tools necessary to use in the building of the machines, and also some articles of a "jobbing" character, in order that the pupil might get an extended experience. Some things made should be of a character that the shop was not equipped to handle, so that methods had to be improvised for carrying out such work, making the pupils resourceful.

It is no advantage for a young man to learn his trade in a shop where there is a machine specially made and equipped for each piece of work done. If he ever gets into a shop where the equipment is limited, and it is necessary to "invent" ways and means for doing certain work, he is apt to fail, as compared with one who has been taught his trade in a smaller and less pretentious shop. The shop should also have a regular cost keeping system. Each boy should be given charge for a given time, and should be expected to get out certain work in a given time, and try to devise means of getting it out quicker and better. The trade school should, in a word, try to teach the young man how to *think* as well as how to *work*.

Can a Boy Learn a Trade in a School?

In answer to the question suggested by the title of this article, the writer would answer: Yes, trades can be successfully taught in schools, provided conditions are made to suit the requirements, and the instructors are equipped by nature and experience with the qualities necessary, and love their work.

* * *

It is stated in the *Mechanical World* that Mr. Muller, a Bavarian inventor, has obtained a patent for a new insulating material which has a high specific resistance approaching that of gutta-percha and porcelain, and at the same time is almost incombustible in that it will even stand exposure for a short time to electric arc without burning. The composition of the insulating material, according to the patent specifications, consists of 100 parts of mineral pitch dissolved in 20 parts of volatile solvent, such for instance as benzine. From 25 to 75 parts of this solution are added to 100 parts of finely ground asbestos. This mixture is then submitted to high pressure, and dried at a low temperature in order that the solvent may be expelled.

FILLING AND PAINTING MACHINE TOOLS.

H. J. HUDDLESTON.*

Almost every plant has its own system for doing machine painting. There are, perhaps, not a half-dozen firms in the city of Cincinnati which do this part of their work alike. I have been in the employ of the R. K. Le Blond Machine Tool Co. during the past eight years, and as this company received the medal for "finish" at the Paris Exposition, its system, which will be explained, is doubtless worthy of consideration.

First, let all the planing and drilling be done on the casting before it is turned over to the painters, for if, after the work has been filled, rubbed down and painted, it is again handled in connection with machining, it will doubtless be necessary to again refill the work, and this cannot be done and the work made to look as it did originally. The casting should first be thoroughly cleaned, and all lumps and rough edges chipped off. All corners and angles should be filed smooth with a bastard file, and then the casting should be gone over thoroughly with a wire brush, which will loosen all sand and dirt. Next take an emery stone and stone it all over. After this has been done, wash the casting with gasoline or naphtha, using a piece of waste. This will take any oil out of the iron which may have accumulated from drilling and handling. After the casting has been washed in this way, it should be dusted, using an ordinary duster.

Now, in every foundry they make good and bad castings; quite often a casting has a blow-hole in it, and it is almost always in a conspicuous place. The S. Obermayer Co., of Cincinnati, Ohio, manufactures what it calls "National iron filler." This ingredient can be used for filling in blow-holes which may be found in castings. It should be mixed with just enough water to give it the consistency of putty. It can then be placed in the blow-hole, and in one-half hour it will be as hard as iron. After all the rough places have been made smooth, and any bad spots filled as described, the work is given a coat of heavy iron filler. Now, there are many kinds of iron filler on the market, but the one which I have found to give the best satisfaction, is the filler manufactured

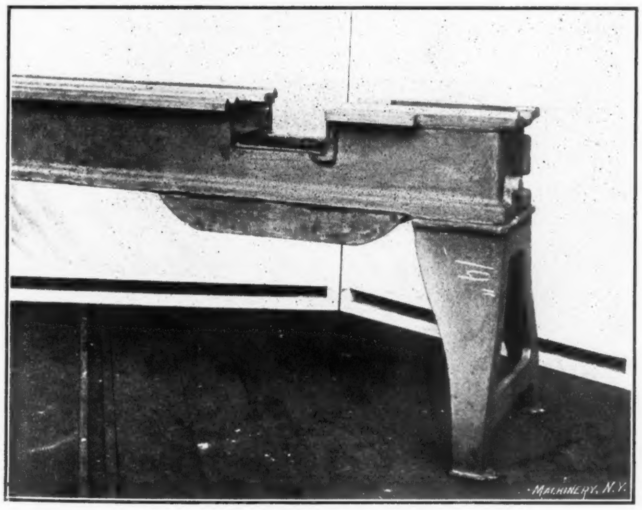

Fig. 1. Lathe Bed and Legs Before Filling.

by the Sherwin-Williams Co. This filler comes in a paste form, and is thinned with turpentine only. After the work has been given a priming coat, it should have about one hour in which to dry. After the filler is dried, the work is plastered. The plastering is done altogether with knives. The knives are of two kinds; one is known as a carrying knife, and the other as a plastering knife. The plastering knives range from 1 to 4 inches in width, while the carrying knives are from 5 to 7 inches in width. The iron filler which is to be applied, is held in a pan, say 12 inches square by 6 inches deep. The filler is thinned with turpentine until it is about like soft putty, then holding the carrying knife in the left hand, and the plastering knife in the right, the filler is applied to the work by cutting some it from the carrying knife with the plastering knife. Hold the plastering knife so as not to pull all the filler off, as it is possible to leave too much filler on the work or to take too much off. It is not well to attempt to handle too much filler on the knives at one time. After going over every part of the work, brush it thoroughly, in this way loosening all the particles of loose or dry filler. The work should now be given three coats of brush-filler, each coat being given about one-half hour in which to dry. The work should now be allowed to set for about five hours; then it can be rubbed.

In putting on the brush-filler, a bristle brush, about 3 inches wide, is the best to use. Care should be taken not to bear too hard on the brush, as brush marks are very hard to sand out. When the work is thoroughly dry and ready to sand, go all over it with No. 1½ emery cloth; then dust it off, and

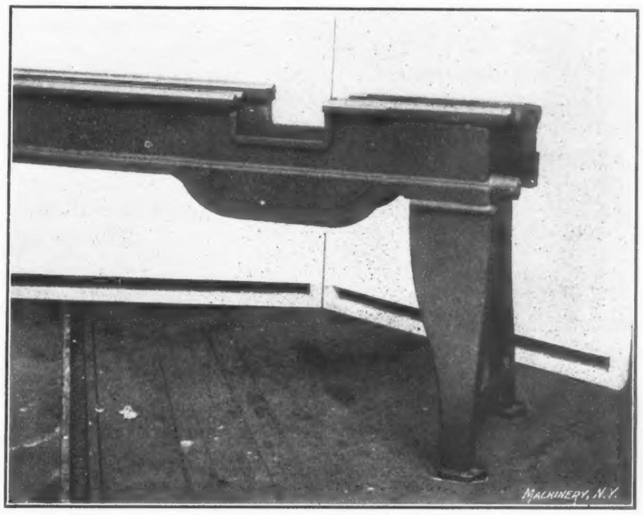

Fig. 2. Lathe Bed and Legs After Filling.

go over it again with No. ½ emery cloth, which will remove all scratches. Again dust the work, and it will be ready for painting.

There is, on the market, what is called an "intermediate surfacer," manufactured by the Sherwin-Williams Co. A coat of this paint will give an elegant body for whatever finish you care to give to the work. A paint suitable for finishing can also be bought from this same company, in any shade desired. If the foregoing directions are followed when painting machine tools, I am sure that the results will be satisfactory.

* Address: R. K. LeBlond Machine Tool Co., Cincinnati, O.

* * *

NOVEL PIPE NIPPLE MACHINE.

The Crane Co., Chicago, Ill., has developed an automatic pipe nipple machine embodying a new principle in pipe threading, we believe. The new principle lies in the action of the cutting dies. These consist of four revolving die heads, set 90 degrees apart around the pipe, which carry chasers on their peripheries and which revolve with the plane of the chaser heads parallel to the axis of the pipe being cut. As the pipe rotates, the rotation of the die heads is kept in step with the lead of the thread being cut, the action being essentially the reverse of the common hobbing process employed in making worm-wheels. The chasers thread the ends of two nipples at the same time. The cutting-off and chamfering tools come into operation after the thread is cut, there being two threaded portions of the pipe between the threading dies and the cutting-off tools. It is obvious that the dies working in this way do not cut a truly tapered thread. The threaded part instead of being a true taper of ¾-inch per foot included angle, is an approximation only, the outlines of the threaded parts being arcs of a circle having the radius of the cutter heads. This deviation from the true shape, however, is so little that it causes no trouble in practice. The productive capacity of this machine is high; when working on ⅜-inch nipples it cuts 10 a minute, the cutters being made of high-speed steel and working at a speed of 70 feet per minute.

* * *

The output of the Baldwin Locomotive Works for the past year was 2,750 locomotives, being an average of 7½ locomotives daily, representing approximately $45,000,000 worth of business.

STANDARD NOTATION FOR ENGINEERING FORMULAS.

At a meeting of the Civil and Mechanical Engineers' Society, in Great Britain, January 2, 1908, the question of standard notation for engineering formulas was discussed by several men well equipped for speaking authoritatively on this subject. One of the most interesting additions to the discussion was offered by Mr. E. Fiander Etchells, who presented the suggestions for a uniform system of notations abstracted in the following. Mr. Etchells called attention to the fact that the real problem was deeper than that simply of notation; the real problem was one of nomenclature. One of the reasons for the condition that, at the present time, there are so many ways of writing the same formula, is principally due to the diversity of names for the same thing. As an example, some writers use S to represent the section modulus of a beam, S being the initial letter of "section," while others, referring to the same quantity, would call it moment of resistance, and would represent it by M or R or even by MR. The first problem, therefore, would be to agree on the nomenclature for the most general engineering and scientific expressions. Having agreed upon this, the following principles might be accepted as a guide for the selection of symbols.

The Initial Letter.

The best symbol to be used, would, evidently, be the initial letter of the word which the symbol was supposed to represent, but this can not, of course, be rigidly adhered to, as in some cases it would lead to confusion, although being adopted for avoiding confusion. In particular, established custom should not be disturbed unnecessarily, for accepted custom, as a rule, represents a natural evolution of unconscious or sub-conscious standardization. Attention was called to the fact that it was not without reason that π represented the ratio of the circumference or periphery of a circle to its diameter, for π is the initial letter of the Greek word περιφερος (periphery), now common on three continents. It would therefore be entirely out of place to try to alter such forms or notations as are already standardized.

Abolition of all Double Symbols.

It would be very inadvisable in any standard system of notation to use any double symbols, for instance, such as BM, representing bending movement, or MR, moment of resistance. Notations of this kind give the impression that M is multiplied by B or by R. Where two letters appear to be necessary, the second letter should be used as a subscript; thus, one would write M_R and M_B, which would be excellent notations for the moment of resistance and the moment of bending.

Self-explanatory Subscript Letters.

Subscript letters should, also, wherever possible, be made self-explanatory. It, for instance, is not at all advisable to say:

A_1 = area of concrete in pillar,
A_2 = area of steel reinforcement,
A_3 = equivalent area.

On the other hand, these three quantities would be very well represented by the notations A_C, A_S and A_E, respectively. Then there would be no need of constantly referring to the explanations of the notations, and the mind would be left free and unhampered to concentrate itself on the real work under consideration. Other things being equal, the less the memory is taxed in grappling with engineering problems, the more it would be possible to arrive at a thorough comprehension of the problems under investigation.

Superscript Letters or Numbers.

Superscript letters or numbers, used at the right-hand top corner of a letter, should be exclusively reserved to represent powers of that letter; thus, whenever the expressions B^2, B^n, etc., are used, it should always indicate the square of B, B in the nth power, etc. Whenever secondary notations are required, and they are not intended to express powers of the principals before them, they should be used as subscript letters, and one should write B_2, B_n, etc.

The Use of Capital and Small Letters.

Capital and small letters may be used to represent related matters; thus, for instance, W may be used to represent the total load, while w would represent the load per inch or per foot of span; P may be the pressure in tons, while p would be the pressure in pounds; L may be the span in feet, l, the span in inches; D may be the external diameter, and d, the internal diameter.

The Use of Greek Letters.

Greek letters should be used very sparingly, and one very important reason for this, which, on consideration, cannot be easily refuted, is because that important factor of civilization, the typewriter, has no such symbols on the ordinary key-board. Greek letters, in general, can easily be dropped, with the exception of the following:

θ = inclination to any horizontal plane; or, in another connection, the angle of torsion; or temperature in the $\theta\phi$, or temperature entropy diagram.
ϕ = inclination to any vertical plane; or the entropy of Clausius definition—*i. e.*, the heat weight of Zeuner—*i. e.*, the thermo-dynamic function of Rankine.
$\pi = 3.141592$.
Σ = "The sum of all such terms as."
τ frequently used for absolute temperature, could easily be replaced by T_A —*i. e.*, temperature absolute; most of the other letters could be treated in the same way.

Use of Initial and Second Letter where Necessary to Avoid Confusion.

The initial and the second letter of a word may be used to avoid confusion, the same as is done in chemistry, or in some cases the initial and the last letter may be used. Thus, just as in chemistry, C represents one atom of carbon, and Ca one atom of calcium, so could d represent the depth of a beam, and d_n or d_e represent the deflection of the same beam. This would save any use of letters not to be found on the ordinary typewriter key-board, such as $\triangle$ or δ. The only alternative is the use of the easily confusible d_1, d_2, d_3, etc., which have already been referred to as undesirable when not absolutely necessary.

In cases of notations for such expressions as "absolute temperature," for instance, one would use T_A, and not A_T. In looking in the index of a book for the expression "absolute temperature" one would look under "temperature" and not under the vague heading "absolute," and in the same way, in engineering notations the principal letter should be the one which expresses the principal meaning. For the same reason S_F is preferable to F_S as an expression of factor of safety, safety being the principal term in the expression. The illustrations given have been used only as examples. Perhaps these examples were not the best ones, but the principles laid down would insure clearness and certainty. While it may not be possible to get a complete standardization of engineering terms, it would be comparatively easy and very desirable that a much greater degree of standardization than existed at the present moment, would be accomplished.

* * *

A MACHINERY data sheet index is now ready for distribution, and copies will be sent to all subscribers upon receipt of request. The index is cumulative and supersedes the one issued December, 1905, as it covers all the data sheets, both regular and extra, issued from September, 1898, to December, 1907, inclusive. The twenty-four extra data sheets issued October, 1907, are included under numbers 74 to 79, inclusive. The total number, including the extra sheets, is 82, or 328 leaves, 6 x 9 inches. These fill the binder supplied by the Industrial Press, and the group will be designated as Volume 1. The next index will date from January, 1908.

* * *

Although so hard, the diamond is very brittle, so that a sharp blow will often fracture it. But Sir William Crookes, who has devoted much time during many years to the scientific study of the diamond, has shown that if a good one is placed between the steel jaws of a hydraulic press, and the pressure is applied without jerk so as to avoid fracture due to brittleness, the jaws may be made to meet without the slightest injury to even the edges of the diamond, the hard steel closing round it and taking an impression of the much harder diamond just like so much wax.—*Times Engineering Supplement.*

GEAR-CUTTING MACHINERY.—4.

RALPH E. FLANDERS.*

As the rack-cutting machines we have just described (see the preceding installment in the March issue of MACHINERY) are derived in form from the milling machine with rack-cutting attachment, so a machine may be made resembling in its movements the arrangement shown in Fig. 65, in which the cutter spindle is mounted on a shaper ram, which is fed forward bodily to pass the cutter through the work. One machine in very common use built on this plan is the Pratt & Whitney rack-cutter. This firm is no longer building this machine, so we do not show a cut of it here, though it is of common occurrence and familiar to every one engaged in the business. Another machine of the same type, built by the R. K. Le Blond Machine Tool Co., is described elsewhere in this issue of MACHINERY.

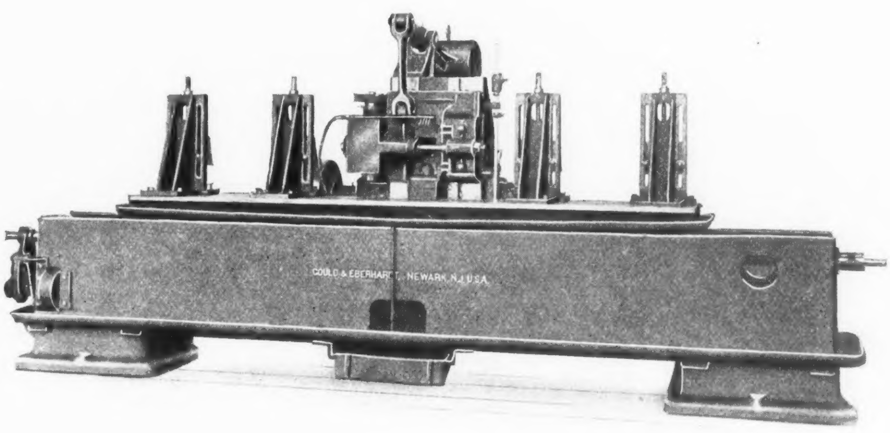

Fig. 69. The Gould & Eberhardt Automatic Rack-cutter.

A third form in which the rack-cutting machine is built, resembles in its construction the heavy type automatic gear-cutter, such as that built by Craven Bros., and shown in Fig. 37. The only difference is in the substitution of a longitudinal work-carrying slide and indexing mechanism, for the rotary work spindle and indexing wheel of the spur-gear machine. This likeness may easily be traced in the case of the Gould & Eberhardt rack-cutter, shown in Fig. 69. As in the spur gear machine, the spindle is mounted on a head sliding on vertical ways on the face of a column. This column may be adjusted in and out on the bed to suit the thickness of the work being operated on. The table, which takes the place of the spindle and face-plate of the spur-gear machine, slides on ways on the main body of the bed. It will be noted that these ways are of unusual length, supporting the table well, even when it is moved out to the extreme of its travel in either direction. The change gears regularly furnished permit the cutting of either diametral or circular pitches. The table can be geared to index in either direction. The work may be fastened either directly to the table by T-slots provided, or may be clamped in the angle vises shown. The cutter spindle is of chrome nickel steel, strongly gear-driven by worm and worm-wheel and splined shafts. The holding of the blank in a vertical position, and the vertical travel of the cutter slide, permit a rigid support for the work against the thrust of the cut, besides causing the lubricant and chips to drop freely out of the way. This type of machine is convenient for setting, inspecting and testing the work. An improved machine of this type is described in the "New Machinery and Tools" department of this issue of MACHINERY.

The machine built by J. E. Reinecker, of Chemnitz-Gablenz, Germany, shown in Fig. 70, like the preceding one, is entirely automatic in all its movements, though it is furnished, if desired, in semi-automatic form in which the spindle head after finishing the cut returns automatically to its starting position, where it stops; the dividing is then done by hand power by the dividing apparatus, after which the feed has to be started again. After the rack is cut through, a special arrangement returns the table to its starting position. This is of great advantage when stocking and finishing cuts are made, as the dividing follows the same direction and from the same starting point.

The driving difficulty previously mentioned as being met with in the rack-cutter, is overcome in this machine in a novel manner—see the line drawing, Fig. 71. As there shown, the cutter spindle is set on an angle with the work, and the forms of the cutters used are made to suit; that is to say, the formed tools used in shaping them are set at the same angle as that given to the axis of the cutter spindle. This arrangement obviously allows the use of a driving gear C considerably larger in diameter than the cutters. The drive is from a vertical shaft D, through a bevel pinion to bevel gear A, driving pinion B, meshing with gear C on spindle E. As here shown, there are two roughing cutters F, and two finishing cutters G. Of course the angularity of the spindle necessitates an increase in diameter for each succeeding cutter on the arbor.

This scheme is especially interesting to the writer because a similar suggestion occurred to him at one time in conversation with a designer who was planning the construction of a rack-cutting machine. In talking the matter over, however, the arrangement seemed inadvisable, owing to the necessity for special cutters and the added complexities of using them in gangs as here shown. Besides this, it would probably be impossible to cut cycloidal teeth of absolutely accurate form by this method, because it would be impossible to obtain clearance for the sides of the cutters at the pitch line where, when absolutely correct, the sides of the teeth are parallel for an infinitesimally small distance. For involute cutters, also, it is obvious that the angle made by the axis of the spindle with the face of the rack must not exceed the number of degrees in the pressure angle (or angle of the sides of the teeth) of the rack being cut. Mr. Reinecker appears to have found this method commercially successful, however, and an actual trial of it is the only true test in a case of this kind.

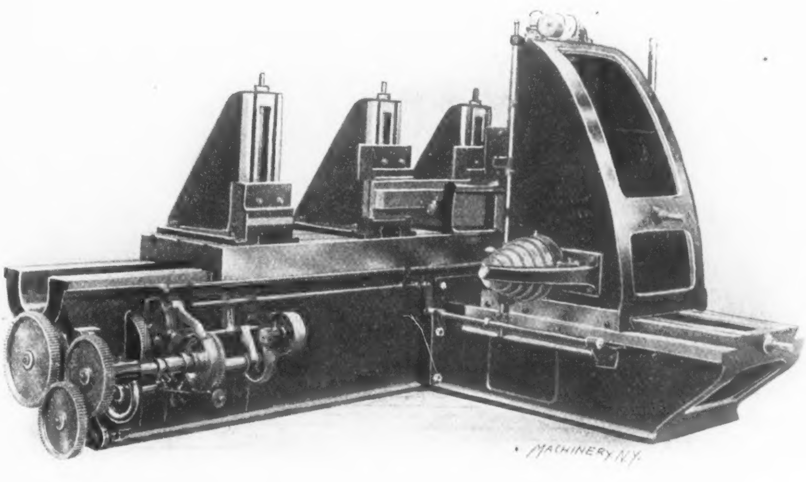

Fig. 70. The Reinecker Automatic Rack-cutter.

Miscellaneous Types of Rack Milling Machines.

The rack-cutter shown in Fig. 72, built by G. Wilkinson & Son, Keighley, England, is built after the planer pattern.

* Associate Editor of MACHINERY.

The cutter head is mounted on a slide on the cross rail on which it travels as it is fed through the work. The work is clamped to the platen of the machine, which is indexed longitudinally for the spacing of the teeth. The indexing is done by hand, though it is not released until the slide has been

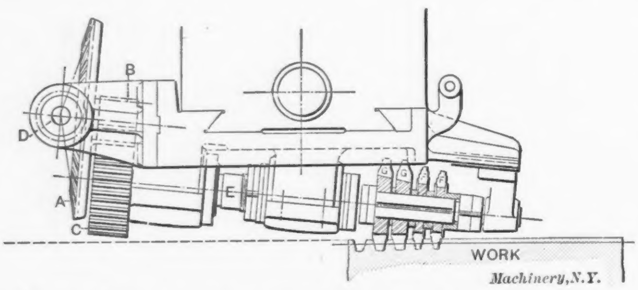

Fig. 71. Diagram showing Angular Position given the Spindle of the Reinecker Rack-cutter to obtain Large Driving Gear at C.

returned to cut a new tooth, this being done automatically, so that there is no possibility of the indexing being done by mistake at the wrong time. The slow forward feed and quick return of the cutter slide are automatic.

Another rack-cutter with the structural features of the planer is shown in Fig. 73. In the case of this machine it will be seen that its ancestors belonged to the "openside," instead of to the standard double-housing family of planers. The movements are about the same as in the previous case, though the machine has an entirely different appearance, and is built for much larger work. It will cut racks up to 1 diametral pitch, 10 inches width of face, 96 inches long, at one setting. For 1 diametral pitch racks, the machine will take one roughing and one finishing cutter. For finer pitches, cutters are used in gangs, as shown in the engraving, up to the full width of space on the cutter arbor. The table is provided with a quick return, operated by power. The machine is regularly made full automatic, but may be furnished in the half automatic style, if desired. It is built by the Walcott & Wood Machine Tool Co., Jackson, Mich.

The rack-cutter shown in Fig. 74 is built by Armstrong, Whitworth & Co., of Manchester, England. The arrangement of the movements is somewhat different from any of the others we have considered. The cutter spindle, as may be seen, is driven by a worm and wormwheel. The feed is effected by the forward movement of the cutter slide on the ways provided for it on the rearward extension of the bed. The spindle itself is mounted on a bracket, which may be adjusted

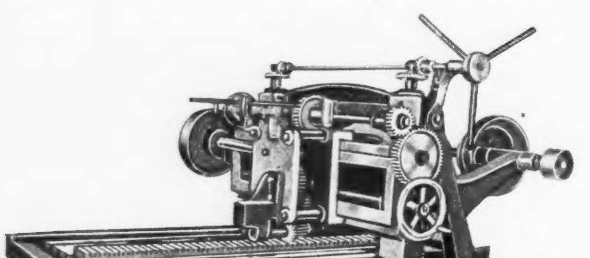

Fig. 72. Planer Type Automatic Rack-cutter, built by G. Wilkinson & Son.

vertically to give the proper depth of cut. One interesting feature of this machine is the provision made for cutting very long racks by shifting the position of the work in the vise when the full range of indexing movement has been exhausted. The central vise indexes step by step, being under the control of the indexing mechanism. The short end vises are screwed to the bed and do not move, the clamp screws with which they are provided being loosened while the work is being indexed. These end vises are used, in shifting the work, to hold it, while the central vise is loosened and returned to the starting point for a fresh grip. The particular machine shown is a somewhat specialized form, built for cutting racks used in wire fence knitting machinery.

The Molding-Generating Method applied to Rack-cutting.

Besides the formed tool method, the only other one commercially applied to rack-cutting is the molding-generating method. The only example of this is in the Fellows system of gear shaping, which is applicable to the cutting of racks as well as to making spur and internal gears. The Fellows gear shaper as arranged for rack-cutting is shown in Fig. 75. This is a smaller size machine than the one shown in Fig. 63, cutting internal gearing, and the arrangement of its parts is somewhat different. In principle, however, it is identical, the same cutter being used and the cutter and work being connected together in the same way. The face-plate or other

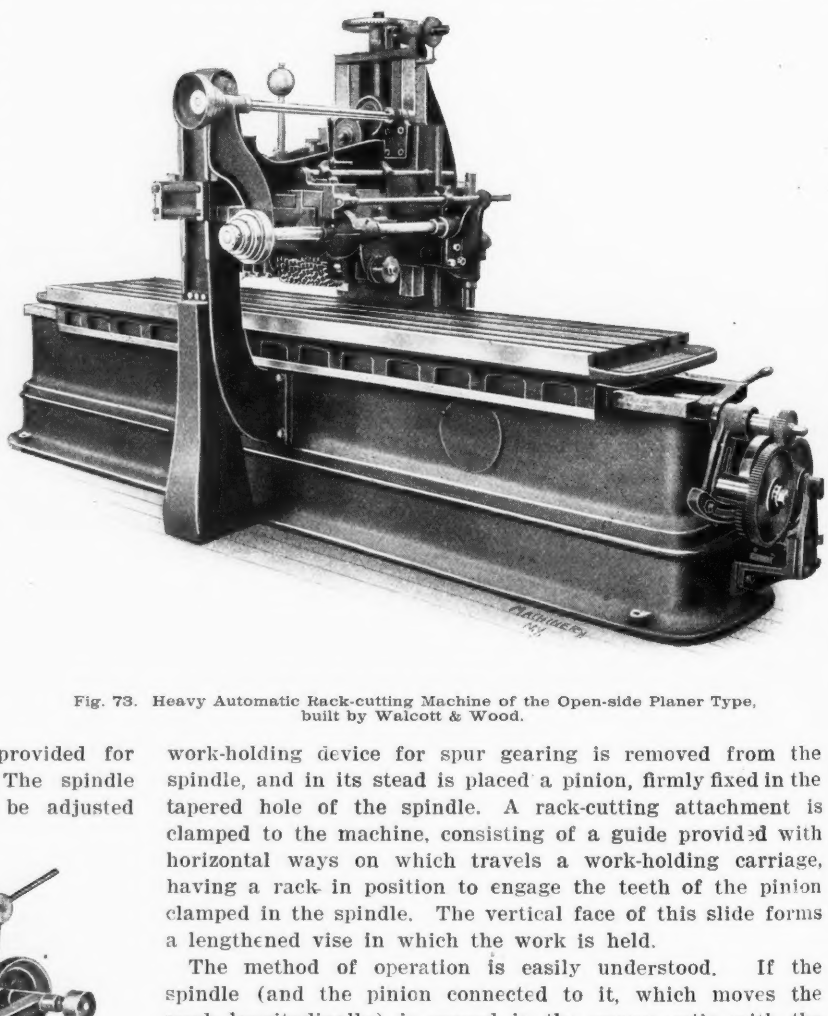

Fig. 73. Heavy Automatic Rack-cutting Machine of the Open-side Planer Type, built by Walcott & Wood.

work-holding device for spur gearing is removed from the spindle, and in its stead is placed a pinion, firmly fixed in the tapered hole of the spindle. A rack-cutting attachment is clamped to the machine, consisting of a guide provided with horizontal ways on which travels a work-holding carriage, having a rack in position to engage the teeth of the pinion clamped in the spindle. The vertical face of this slide forms a lengthened vise in which the work is held.

The method of operation is easily understood. If the spindle (and the pinion connected to it, which moves the work longitudinally) is geared in the proper ratio with the cutter, the machine may be started up with the cutter at the starting point, when the cutter will roll on the work, exactly as if it were a pinion, and the work were a rack with which it engaged. Under these circumstances the shaping action of the cutter will form rack teeth in the work, of suitable shape to mesh with all the gears in the series to which the cutter belongs. The operation is the same as shown in Fig. 8, except that it is reversed. Instead of having the rack the cutting tool and the gear the work, the gear is the cutting tool engaged in forming teeth in the rack. In addition to using an attachment to the regular machine, as in this case, the Fellows Gear Shaper Co., Springfield, Vt., have made special rack-cutters involving this principle, in which the work table slides on a long bed, as in Figs. 69 and 70.*

* Described in article entitled "Fellows Rack Shaper," in the December, 1901, issue of MACHINERY.

This completes the consideration of machines for cutting spur gears, internal gears and racks.

MACHINES FOR FORMING THE TEETH OF WORMS, AND OF SPIRAL AND HERRING-BONE GEARS.

Spiral gearing, twisted and herring-bone gearing, and worm gearing, are all radically different in their action. The first two forms, however, and the worm member of the third, are identical so far as the principles governing the forming of their teeth are concerned; so we will consider them together in this section of this series of articles. It might be mentioned in connection with the name "spiral" gearing, that gears of this kind are not spiral at all, but helical. A spiral is a figure contained in a plane. It has the same shape as the ordinary watch or clock spring, starting from a central point, about which it circles in widening curves. A helix has the shape of a string wound around a cylinder. The name "helical" has come into common use in describing springs of helical shape, and it ought to be used for gears as well. The writer would suggest that the reader practice using the term "helical gear." Criticism might also be directed toward the term "spiral staircase," but since carpentry is out of our field, we will not spend any time here in inaugurating that reform.

Almost as great a variety of methods of cutting teeth are possible for helical as for spur gears. Commercially, however, the two important principles are the formed tool and the molding-generating methods. The templet, odontographic and describing-generating methods of cutting gear teeth (in each of which the outline is worked out by the *point* of a tool, suitably constrained) are most useful for cutting gears of large size, in which tools acting on the formed tool or molding-generating principle would be subject to too heavy cuts. Since helical gearing is generally confined to small and medium sized work, these processes are unnecessary, being by nature rather slow in action, and dependent for their accuracy on the preservation of the shape of easily injured points of comparatively small cutting tools. As in the case of spur gears, the molding-generating method is of comparatively recent introduction, and is confined almost wholly to the production of teeth of involute form.

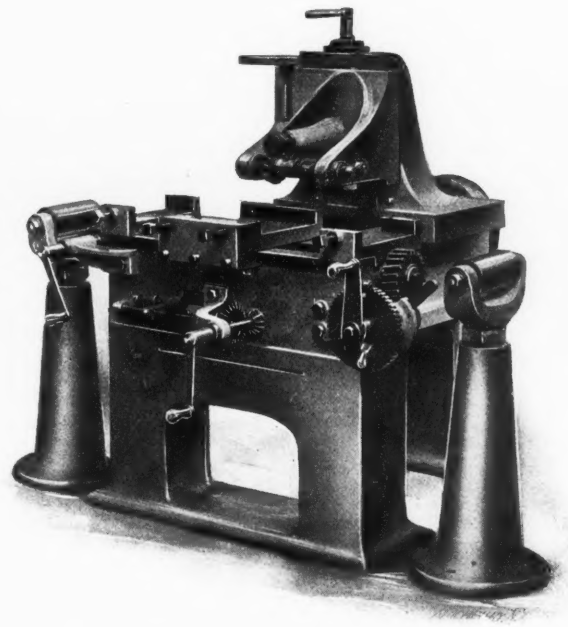

Fig. 74. Armstrong-Whitworth Automatic Rack-cutter.

Machines using Formed Tools in a Shaping or Planing Operation.

With the twisted teeth which we have in gears of the class we are discussing, it is evidently necessary, in employing shaping or planing operations, to give a rotary movement to the blank being operated on, at the same time as, and in the proper ratio with, the cutting stroke of the tool. This is necessary to compel the tool to follow the helix on which the teeth of the gear or the worm are to be formed. In Figs. 76 and 77 are shown two attachments for the shaper, working on different principles, giving the work the proper motion for cutting helical teeth. Both of these attachments were built by Gould & Eberhardt, of Newark, N. J.

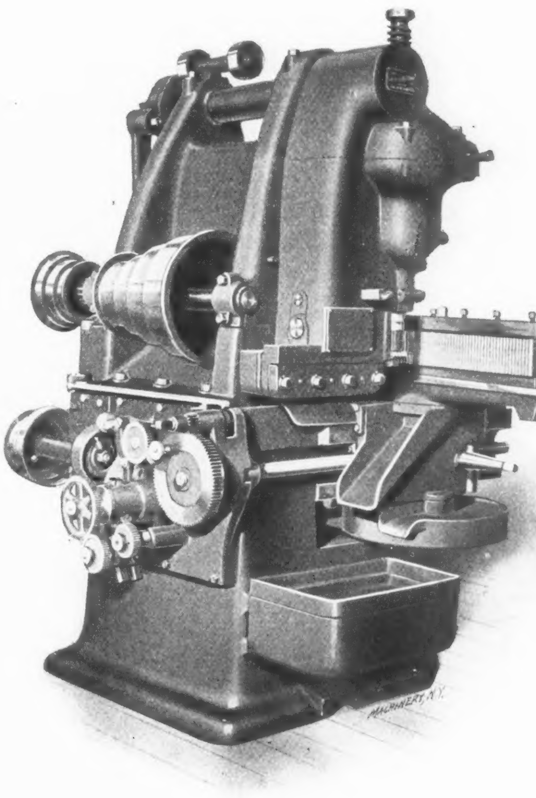

Fig. 75. The Fellows Gear Shaper, with Rack-cutting Attachment.

In the first of these, Fig. 76, the work is mounted between centers on a supplementary bed, fastened to the work table of the shaper. The face-plate by which the work is driven from the head-stock spindle is connected to that spindle by an indexing mechanism, consisting of a notched plate, with a locking bolt for holding the work in the different positions for the different numbers of teeth required. The head-stock spindle is connected, by spiral gearing and a set of change gears, with a pinion operated by a rack, which rack is fastened to the shaper ram. It will be seen that this connection with the shaper ram will give a rocking movement to the head-stock spindle and the work, in unison with the stroke of the tool. By selecting suitable change gears, this rocking movement may be made of any desired amplitude for a given length of stroke, so that any lead of helix or spiral desired may be obtained. Provision is made, in the means by which the rack is attached to the ram, for raising or lowering the work

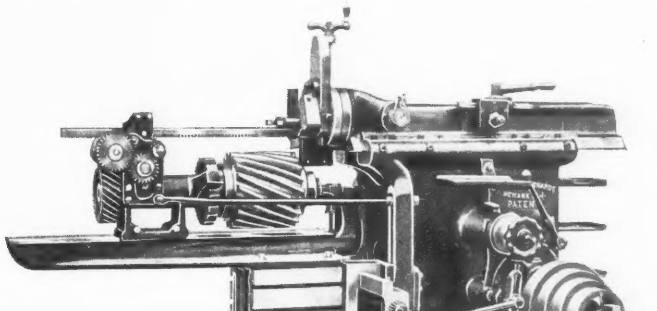

Fig. 76. Helical Planing Attachment for Gould & Eberhardt Shaper, in which the Lead of the Helix is obtained by Change Gears.

table to the position required for different diameters of work. The tool is, of course, fed downward by hand, and the indexing is done manually also. On the floor at the base of the machine will be seen a pair of right- and left-handed helical gears, similar to the one being operated on; the two form a herring-bone gear.

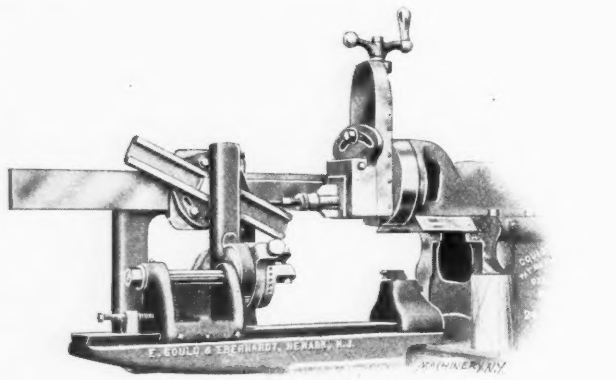

Fig. 77. Helical Attachment for Gould & Eberhardt Shaper, in which the Lead of the Helix is obtained by the Adjustment of a Swiveling Guide Bar.

The second attachment, shown in Fig. 77, employs a radically different principle for varying the amplitude of the rocking movement of the head-stock spindle for a given stroke of the ram, to obtain different leads of helix. The reader, of course, understands that the lead of the helix is the length of the cylinder required to allow a complete revolution of the helix. In this case, a spur gear keyed to the head-stock spindle meshes with a vertical rack, sliding in a guide which is cast integrally with the head-stock. This vertical rack is pivoted to a block which slides in a guide attached to a swiveling head, so that the guide may be adjusted to any angle. This swiveling head, in turn, is attached to a bar, which is fastened to the ram, and is guided on ways supported by a framework at the back of the head-stock. It will thus be seen that the forward and backward movement of the ram will impart an up and down movement to the rack, which will, in turn, give a rocking movement to the spindle of the head-stock, and the work which it drives. The amplitude of this rocking can be increased or diminished by setting the swiveling guide at a greater or less angle, so that the helices of various leads can be obtained. This makes the use of change gears unnecessary. The indexing device is similar in principle in the two arrangements.

It will seem strange at first thought, perhaps, to describe the cutting of worms in a lathe as an example of the use of formed tools in shaping or planing operations, but the operation is essentially the same as that shown in Fig. 76. Compare this with Fig. 78, imagining that the lead-screw shown

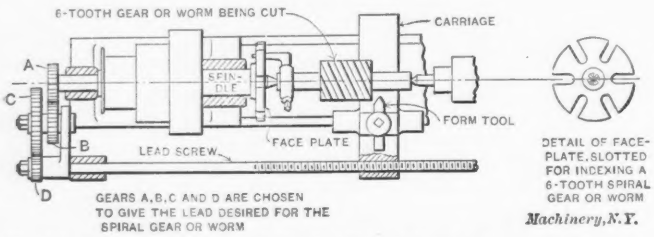

Fig. 78. The Lathe Method of Planing Helical Teeth in Gears or Worms.

in the latter is of such steep pitch that it can be rotated by pushing the carriage backward and forward. Under these circumstances, if provision is made for reciprocating the carriage (corresponding to the ram for the shaper), the lead-screw will be rotated in unison with it, and this movement will be transmitted through change gears *A*, *B*, *C*, and *D* to the head-stock spindle, giving a rocking movement to the work. The only difference in the two cases is that in the lathe a screw of very steep pitch would be used to change the reciprocating motion of the tool to the rocking motion required by the work, while in the case of the shaper the more natural rack and pinion movement is employed. In the case of the lathe, of course, the power is not applied to the carriage but to the spindle. For that reason it is best adapted for cutting spiral gears of comparatively small lead, or "worms" as we ordinarily call them. If it were attempted to cut 45-degree spirals, for instance, the lead-screw would have to be speeded up so fast, as compared with the movement of the spindle, that the driving belt would be unable to operate the machine. Special lathes have been built for cutting steep worm threads, in which the power has been applied to the lead-screw, the spindle being driven from it through the change gears. A lathe so arranged would have as much difficulty in cutting fine pitches as the ordinary lathe does in cutting coarse ones.

Different methods of indexing may be used for the lathe. It will be noticed that in Fig. 78 the face-plate used has the same number of slots as the required number of teeth. After one tooth space has been cut, the work can be removed, and replaced again between the centers with the tail of the dog in another slot. After this space has been completed, the next one is cut, and so on until the whole six are finished. Other methods are in use, such as slipping of change gears *A* and *B* past each other a certain number of teeth, as determined by calculation.

Special lathes are built for threading, some of which are automatic in their action. One of these is shown in Fig. 79. It is built by the Automatic Machine Co., Bridgeport, Conn.* The size shown is especially adapted to cutting worms. It is provided with mechanism for duplicating the action of a

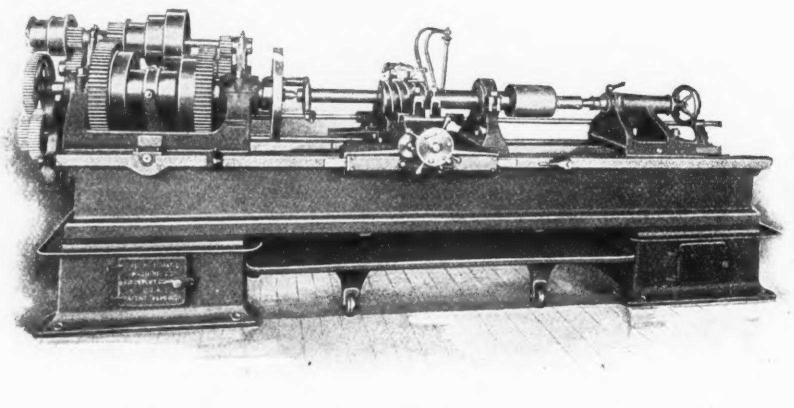

Fig. 79. Automatic Threading Lathe for Worms, made by The Automatic Machine Co.

manually operated lathe engaged in threading. After a piece of work has been placed between the centers and the machine has been started, the work revolves, and the carriage feeds forward until the proper length thread has been cut; then the tool is withdrawn, and the carriage returns to begin again on a new cut—and so on without attention from the operator. The tool is fed in a certain suitable amount, at the beginning of each cut, the amount of this feed being automatically diminished to give a fine finish for the final cuts. When the depth for which the tool has been set is reached, the operation of the mechanism is automatically arrested. In cutting multiple threaded worms in this machine, multiple tools may be used, thus avoiding the necessity for indexing the work. As many as eight cutting tools have been used at once on this machine, giving a total length of cutting edge of 8 inches.

Machines Using Formed Milling Cutters.

We have spoken hitherto of the formed tool or cutter method of shaping the teeth of gears, as being one in which the tool accurately reproduces its shape in the tooth space it forms. This is true in cutting straight tooth spur gears, and in planing the teeth of spiral gears by the process just described. It is not exactly true, however, of any possible process of milling spiral teeth. This is best seen in Fig. 80. In the three cases here shown, we have first, a planer tool; second, a disk milling cutter; and third, an end milling cutter—all formed

* See "New Tools of the Month" section of MACHINERY, February, 1908.

to the same identical outline, and cutting helical grooves of the same lead and depth in blanks of the same diameter. The section in each case is a plane one, taken normal to the helix at the pitch line. (Of course the true section to take would be that of the helicoid normal to the helicoid of the groove being cut. The plane in which we have taken the section, however, so nearly approximates this helicoid that the error is negligible.)

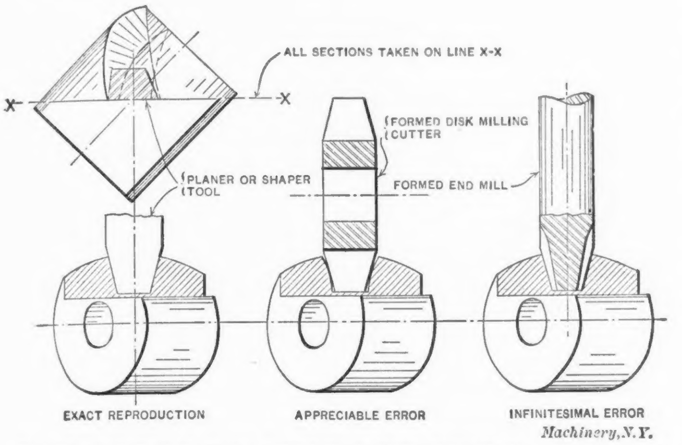

Fig. 80. Comparison of the Accuracy of Form Reproduction Obtainable by Formed Planing Tool, Formed Disk Cutter, and Formed End Mill.

The planer tool necessarily cuts a groove of the same shape as its outline, the plane of its outline being the same as the plane of the section shown. The disk milling cutter, however, interferes with the sides of the groove it cuts. This interference takes place on one side as the teeth are entering, and on the other as the teeth are leaving. This results in a generating action, which takes place in addition to the simple forming action, so that the tooth cut is not an exact duplicate of the outline of the cutter. In the case of the formed end mill there is also an interference of the same kind as with the formed disk cutter, but it is so slight as to be absolutely undetectable, in all ordinary cases. We only know of its presence from theoretical considerations.

In spite of its imperfect reproduction of the desired form, the disk cutter is the type generally used for milling, since it may be so relieved as to retain its shape even after repeated grinding. The end mill type of formed cutter cannot remove so much stock in a given time, and it is difficult to make it so that it can be ground without changing its form. The only way in which this grinding can be practically performed, is by the use of some form of templet grinding machine,* such as has recently been described in these columns. The formed end mill is used to a limited extent, nevertheless.

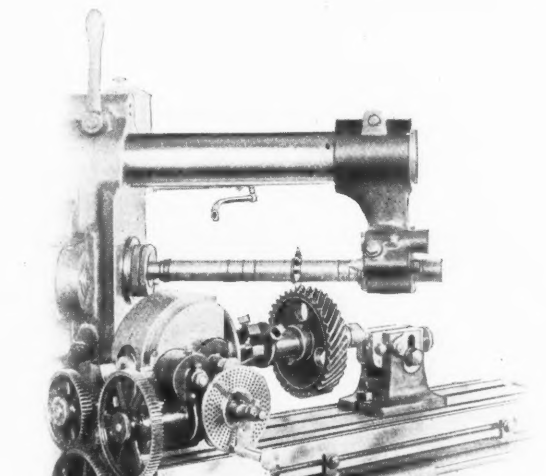

Fig. 81. Brown & Sharpe Milling Machine arranged in the Usual Manner for Cutting Spiral Gears.

* See article "Notes on the Manufacture and Up-keep of Milling Cutters" in the engineering edition of the March, 1908, issue of MACHINERY.

The simplest way of using the milling process for cutting helical gears or worms, makes use of the universal milling machine. With this machine, the work, and the feed-screw of the table on which it is mounted, are so connected by means of gearing that the forward feeding gives a rotary movement to the work, producing a helix of the required lead. The mechanism is identical in principle with that shown in Fig. 78 for the lathe, and in Fig. 76 for the shaper, the only difference being that in the milling process the longitudinal movement is a steady feeding motion, made once for each tooth space, instead of being a continuously reciprocating motion, as in the previous cases. The simple indexing devices shown in Figs. 76 and 78 are replaced by the more elaborate index plate and worm-wheel device of the spiral head.

This mechanism, as exemplified in the Brown & Sharpe universal milling machine with its spiral head, etc., is illustrated in Fig. 81. The work has to be swung at an angle with the cutter to agree with the helix angle at the pitch line, as indicated. This is done by swiveling the table of the universal milling machine to bring the work to the proper angle with the cutter. In most makes of machines, it is inconvenient, if not impossible, to swivel the table to a greater angle than 45 degrees. For greater angles, special attachments are provided for swiveling the cutter, leaving the table in its normal position at right angles to the spindle of the machine. Two examples of this are shown in Figs. 82 and 83. The first case, Fig. 82, shows a Brown & Sharpe milling machine engaged in cutting a spiral gear, using for the purpose a vertical milling attachment, which has been set to the required helix angle. The change gearing used for connecting the spiral head with the feed-screw of the table can be plainly seen at the left. In Fig. 83 an attachment of another form is shown, built by the Cincinnati Milling Machine Co., Cincinnati, Ohio. In this case the cutter is adjustable about a vertical axis, being driven from the spindle by bevel and spiral gears. It may be set at any angle throughout the whole circle, and cuts on top of the blank, the table being set in the normal position, the same as in Fig. 82. The vertical attachment shifted to a horizontal position, or a rack-cutting attachment, may also be used in milling helical gears to bring the cutter spindle at right angles to the main spindle of the machine. By this means it is possible to mill gears having a greater helix angle than 45 degrees, without shifting the table more than 45 degrees, since the table is set at the complement of the helix angle, thus making it possible to cut even fine pitch worms.

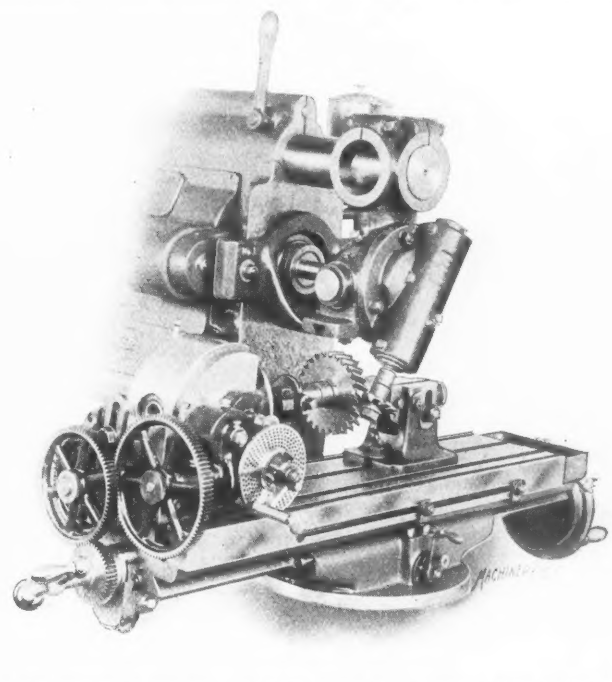

Fig. 82. Cutting Spiral Gears of Helix Angle too Great to Allow the Method of Fig. 81; employing the Brown & Sharpe Vertical Milling Attachment.

These various attachments allow the milling machine to work throughout a wide range of angles for helical gears and

worms, the only limitation being one similar to that imposed on worm cutting in the lathe, though the limitation is reversed. For worms or gears of too small lead as compared with their diameter, the rotary movement of the blank is so great that

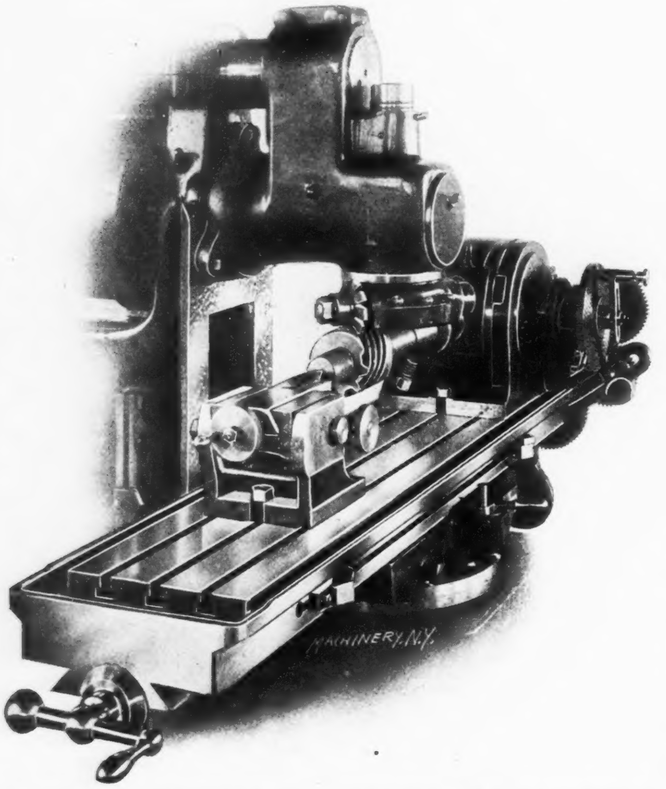

Fig. 83. Universal Milling Attachment of the Cincinnati Milling Machine Co. in use Cutting Gears of Large Helix Angle.

the comparatively slow-moving feed-screw is unable to speed up the spiral head mechanism to get the required movement, and still furnish power enough for feeding the work against the cutter.

Specialized Forms of Milling Machines for Cutting Spirals by the Formed Cutter Method.

The principle of the universal milling machine for cutting spiral gears and worms has been applied to the design of various special machines for the same purpose. A number of these are shown in Figs. 84 to 88. The specialization of the machine includes making the spiral and indexing mechanisms integral parts of the tool, so that they have a much greater capacity for taking heavy cuts than is the case where they are merely attachments, as in the cases previously shown.

In the first case we show, the spiral cutting mechanism is still something in the nature of an attachment, the machine being designed for cutting other kinds of gears as well. This tool (see Fig. 84) is the universal gear-cutting machine made by Nya Aktiebolaget Atlas, Stockholm, Sweden, already illustrated in Figs. 34 and 61. The cutter spindle is mounted in a swiveling head, which may be set at the required angle for the helix to be cut, the angular adjustment thus being identical with that in Fig. 83. The cross rail with the cutter is fed down through the work, which is rotated by its gearing connections so as to produce the helix required. In this machine, the indexing is done by power, being regulated by change gears as in the orthodox automatic spur gear cutter. There must, then, be some sort of a differential gear mechanism combining the indexing movement and the rotation of the work for the helix, both of which must be allowed to operate on the work without interfering with each other. We are not informed as to the exact nature of this mechanism, though it is doubtless similar in principle to that described for the following machine.

It was stated that the spur gear cutting machine shown in Fig. 51 is a modification of a universal gear cutting machine made by J. E. Reinecker, of Chemnitz-Gablenz, Germany. In Fig. 85 is shown a side elevation, and in Fig. 86 a diagram of the index worm connections, of the universal machine referred to, as arranged for cutting helical gears by the formed milling process. The machine is arranged, like the Becker-Brainard machine (see Fig. 20), on the general lines of the milling machine, excepting that the work spindle is at the top of the column, and the cutter spindle on the knee.

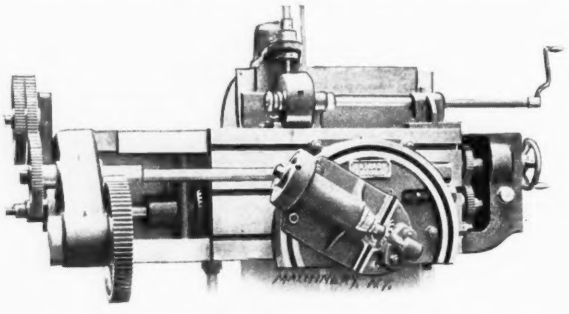

Fig. 84. Helical Gear-cutting Attachment used with the Atlas Gear-cutting Machine shown in Fig. 34.

The cutter, at *B*, is driven by an internal gear *A* of large diameter (see also Fig. 51) and is mounted on a swivel table *C*, which can be set to the required helix angle. The form of cutter slide shown will give any angle up to 30 degrees. For greater angles, this is replaced with a slide which can be rotated to any angle throughout the whole circle.

The screw which feeds cutter slide *C* along the knee is driven from cone pulley *D*, through vertical shaft *E* and its gear connections. Cone pulley *D* is also connected with change gearing *F*, which is, in turn, connected with the index worm, so as to rotate index wheel *G*, and the work properly for any desired helix. The principle of this is the same as in the universal milling machine, change gears *F* acting the same as the change gears used to connect the spiral head with the table feed-screw in Fig. 81. Now the worm-wheel *G* is used for indexing, as well as for rotating the work for the helix,

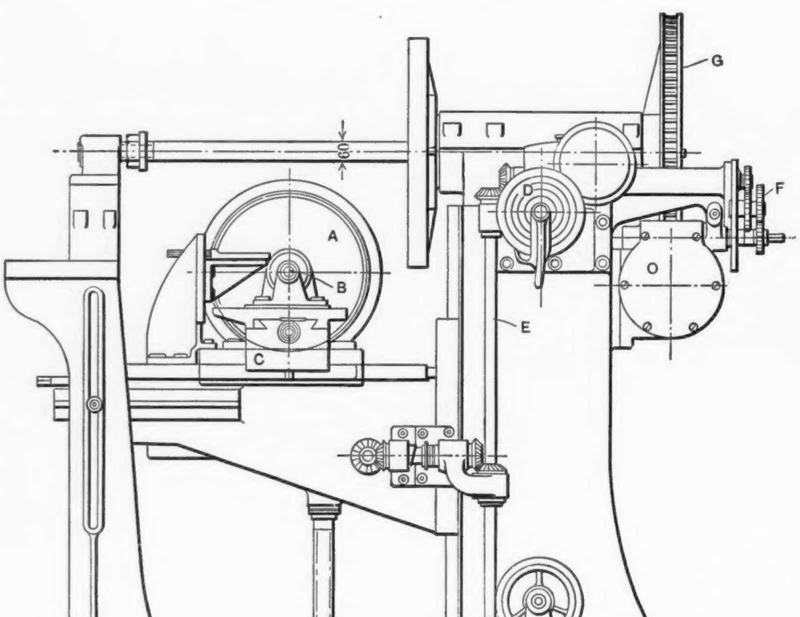

Fig. 85. Side View of the Reinecker Universal Gear-cutting Machine, showing the Geared Connections between the Index Worm-wheel and the Feed of the Cutter Slide.

in unison with the feeding of cutter slide *C*. The way in which these two motions are imparted to *G* without interfering with each other, may be understood by reference to Fig. 86; similar parts have similar reference letters in this engraving and the preceding one.

At *H*, on the opposite side of the machine from that shown in Fig. 85, are mounted the change gears by which the index-

ing is accomplished. These gears drive bevel gear *J*. Index worm *K*, meshing with index worm-wheel *G*, is mounted on a hollow sleeve, keyed fast to the bevel gear *L*. Shaft *M* carries a hub with projecting pivots on its right-hand end, on which are mounted bevel pinions *N*. Shaft *M* is driven by worm-wheel *O*, connected with the feed of the slide cutter through change gears *F*. Gears *J*, *L* and *N* form a differential mechanism of the well known "jack-in-the-box" type. The

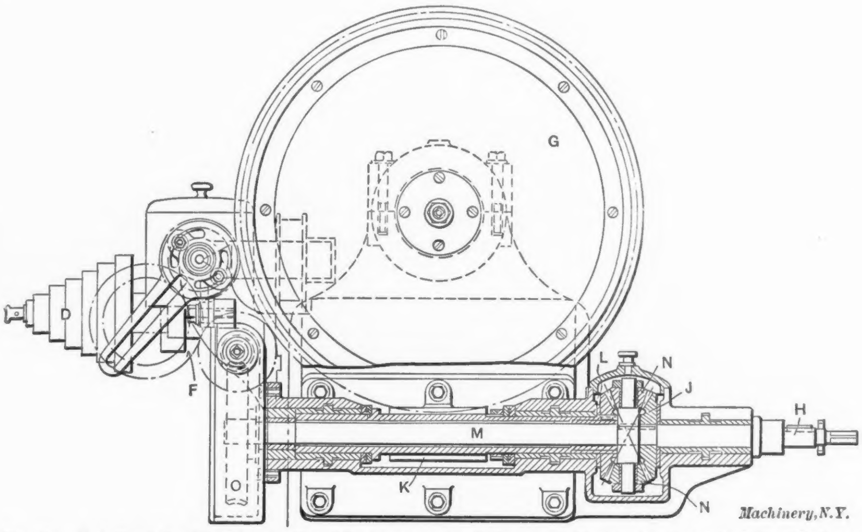

Fig. 86. Detail of the Machine in Fig. 85, showing the Differential Mechanism by which the Motions for Helical Cutting and for Indexing are combined to Rotate the Work.

action of this mechanism is such that if shaft *M* be at rest, change gears at *H* may be operated for the indexing, transmitting the motion from gear *J* to *L* through pinions *N* as idlers, thus revolving index worm *K*. On the other hand, with the indexing mechanism still and the cutter slide feeding, the movement thus imparted to shaft *M* may be transmitted (by the rolling of pinions *N* on stationary bevel gear *J*, and the consequent rotation of bevel gear *L*), to worm *K*, and thence to worm-wheel *G* and the work. It will thus be seen that the indexing, and the rotation for the helical cutting, can take place independently of each other. But more than this, the two motions can be operated together without interference. In fact, either of the motions imparted to shaft *M* or gears at *H*, may be stopped or reversed independently, and each will have its proper influence on the index wheel and the work.

With this understanding of the differential mechanism, the operation of the machine is easily comprehended. Change gears *H* are connected through a one-revolution friction trip with the main driving shaft. The cutter, set at the proper angle, is fed forward through the work, which is rotated by change gears *F*, shaft *M*, and worm *K*, at the proper rate to cut the proper helix. The cutter is then dropped down to clear the work (provision for this being made in the machine), and returned, ready to begin on a new tooth. The indexing mechanism is then tripped by hand, and the work is rotated into position for the new tooth, by change gears at *H*, gear *J*, and worm-wheel *K*. This is repeated until the gear is done.

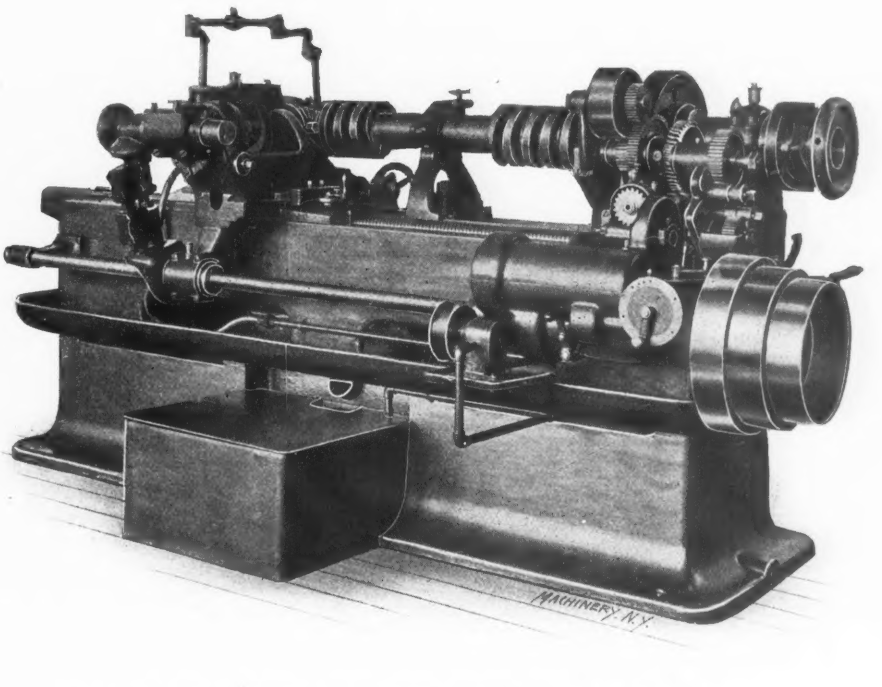

Fig. 87. The Pratt & Whitney Thread Milling Machine, engaged in Cutting a Worm.

A gear-hobbing machine made by Maschinenfabrik Lorenz of Ettlingen, Baden, Germany (to be described in the next installment of this series), cuts spiral gears in a fashion similar to the Reinecker machine just described. Owing to the fact that it is primarily designed for hobbing, however, it will be described with other machines of that type.

In the machines hitherto shown, power is applied to the feed-screw, from which the work is rotated through change gearing. This arrangement is best for helices of great lead. When it comes to milling helical gears with small leads, or worms, it is necessary to use the lathe principle and apply the power to rotating the work, the longitudinal feed being driven from the work spindle through change gearing. We show two examples of machines of this kind in Figs. 87 and 88.

The well-known thread milling machine made by Pratt & Whitney, Hartford, Conn., is illustrated in Fig. 87. Probably few mechanics have ever thought of this as being a gear-cutting machine, but it is here shown engaged in the perfectly legitimate work of cutting a worm, so that it should be classified with gear-cutting machinery of the kind described in this section of the article. The machine is so well known as to scarcely need description. The cutter spindle is mounted in a head which can be swiveled to any angle, and the slide which carries it is fed lengthwise along the bed, the proper lead being obtained by connecting the head-stock spindle and feed-screw by change gearing.

A second machine of this kind is shown in Fig. 88. It is built by J. E. Reinecker, of Chemnitz-Gablenz, Germany, and is intended especially for milling worms, although it is well adapted for small spiral gears also. The cutter, driven by worm gearing, is mounted in a heavy swiveling head, which is fed along the bed on ways at the rear of the machine. The adjustment for diameter is made by moving the work table, with its head- and foot-stocks, away from or toward the cutter. Cone pulleys and gearing are provided for varying the rate of feed of the cutter head, while the connection between the feed movement of the cutter and the rotation of the work is governed by change gears. On the worm-wheel which drives the work spindle will be seen mounted a change gear mechanism which is used for indexing. The indexing is by hand, and the whole mechanism is carried around by the spiral movement, so that a differential mechanism is unnecessary.

Specialized Form Milling Machines for Herring-bone Gears.

A machine for helical gear cutting, but provided with some special features, is shown in Fig. 89. This machine is used by C. E. Wüst & Co., Seebach, Zurich, Switzerland, for cutting

herring-bone gears of a special form, in which it is unnecessary to cut the two halves separately, in separate sections, as is the usual case. As may be seen in Fig. 90, the cuts are staggered so that the teeth on one side run into the spaces on the other, in such a way as to permit cutting them with rotary cutters without having one side interfere with the other. The machine for doing this is built on a very simple plan, as may be seen. It consists of a vertical spindle carrying the work, which is apparently indexed by power. The

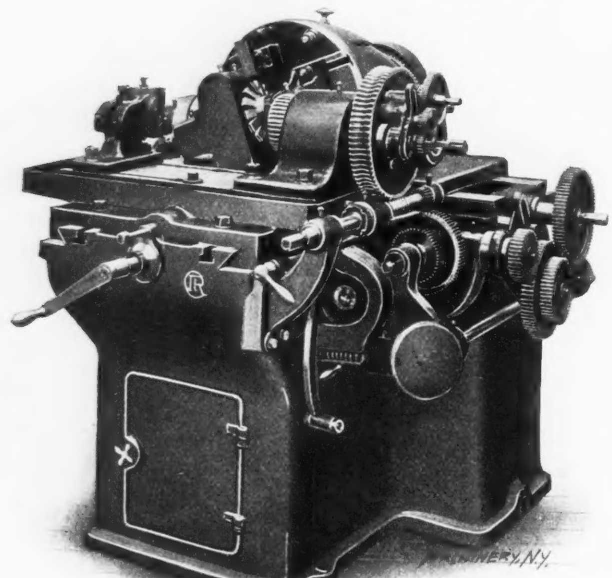

Fig. 88. The Reinecker Worm Milling Machine.

indexing wheel is connected by the usual change gearing with the two vertical slides on which the cutters are mounted on either side. These cutters work simultaneously, one feeding downward to cut the upper half, while the other is feeding upward to cut the lower half. It is not possible to say, from the information at hand, whether or not the machine is fully automatic. Probably it is not. The most interesting thing about the machine is its product; the large gear shown in the machine in Fig. 89, and the pinion shown in Fig. 90, are examples of two extremes in the range of work for which the process is applicable.

There is another specialized form of herring-bone gear which has been illustrated in MACHINERY,* that made by André Citroën & Co., 202 Rue de Faubourg St. Denis, Paris. The teeth of these gears, we are informed, are shaped by an

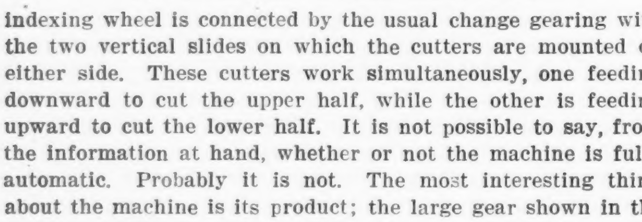

Fig. 89. Machine for Cutting Solid Herring-bone Gears by the Wust Process.

end cutter like that shown in Fig. 80, guided by suitable mechanism to produce the continuous "wavy" form of herring-bone teeth characteristic of these gears. This process also has the advantage of not requiring the blank to be made in two pieces. The same principle has been applied by the builders to the cutting of herring-bone bevel gears.

Other manufacturers make use of the formed end mill, to a limited extent, at least. The arrangement devised by Gould & Eberhardt for milling large helical gears in the lathe, recently illustrated in MACHINERY,* used this form of cutter, and the worms or spiral gears which drive the racks of the Sellers drive planers, made by at least one of our prominent planer builders, are cut by end mills in a specialized milling machine of simple design, made especially for this purpose.

* See article "Herring-bone Gearing with Cut Teeth," in the engineering edition of the April, 1903, issue of MACHINERY.

* See Figs. 3 and 4, in the article entitled "Emergency Methods in Gear Cutting," in the November, 1907, issue of MACHINERY.

* * *

PAINTING GALVANIZED IRON.

It is well known that ordinary paints will not adhere for any length of time to galvanized surfaces, unless the surface has been exposed to the weather for a long time—and not always then. Galvanized materials are usually dipped in a non-drying oil for the purpose of preventing atmospheric corrosion, and this neither combines with paint, nor permits a bond between the surface and the paint. Even when this oil has been removed, ordinary paints will not adhere to the zinc surface, and it is necessary to prepare the surface by changing it to an oxide of zinc. Exposure to the weather does this naturally, but slowly. The same thing may be accomplished in a short time by neutralizing the oil by an acid. The acid also forms a thin coating of zinc oxide, to which certain paints adhere very well. A very satisfactory wash for the purpose indicated consists of two ounces each of copper chloride, copper nitrate and sal-ammoniac, all dissolved in one gallon of soft water. After these are dissolved, add slowly two fluid ounces of crude hydrochloric (muriatic) acid, and stir carefully. Do not inhale the fumes. Of course, the solution must be made and kept in glass or earthenware jars or bottles, not only to avoid corrosion of the containing vessel, but to prevent precipitation of the copper salts.

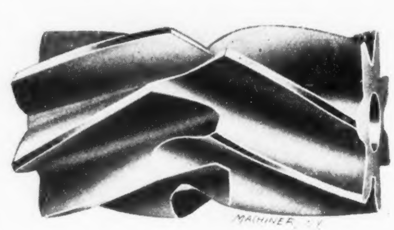

Fig. 90. A 7-tooth Pinion, Formed by the Wust Process.

Cover the surfaace to be painted with this solution, using, preferably, a wide brush. The black appearance of the surface which immediately follows disappears within a few hours, and is replaced by the gray appearance characteristic of zinc oxide, the same as is seen after galvanized surfaces have been exposed to the weather for several months. Red lead, mixed with raw linseed oil and turpentine, half and half, will adhere very well to this surface. This may be followed by coats of any desired paint. A preliminary wash of vinegar, nine parts, and muriatic acid, one part, is recommended. It is to be followed by a priming coat of Prince's mineral brown, thinned with turpentine. Still another wash, consisting of nothing but vinegar or another dilute acetic acid, is recommended as giving satisfactory results in most cases. This, also, is to be followed by a priming coat of Prince's mineral brown, as above.

O. M. B.

* * *

A gas engine of rather interesting design is described in a recent issue of the *Engineering Record*. In this design, the so-called "hit-and-miss" type of valve mechanism has been applied to the exhaust valve, the gear being spring-retained in its unlatched or inoperative position, so that unless specially actuated, the valve does not open to exhaust on the exhaust stroke. The spring, holding the latch or dog, is attached to a piston in a miniature cylinder, connected with one side of the main engine cylinder at such a point at the crank end that the engine piston uncovers the opening at the extreme outer stroke only, and admits the pressure of the exploded gases. The movement of the exhaust valve is so timed in relation to the admission of pressure to the miniature cylinder that the latch, which is forced out by the piston in the latter, is caught, and causes the exhaust valve to open for the regular exhaust of the cylinder; but, if the explosive mixture should not explode, due to omission of spark for speed regulation, then the miniature piston is not actuated, and the explosive charge is not exhausted and wasted, as with the usual gas engine construction.

JIGS AND FIXTURES.—1.*

EINAR MORIN.†

Einar Morin.‡

Jigs and fixtures may be defined as special devices made of cast iron, steel, or sometimes of wood, used in the manufacture of duplicate parts of machines, and intended to make possible interchangeable work at a reduced cost, as compared with the cost of producing each machine detail individually. The jigs and fixtures serve the purpose of holding and properly locating a piece of work, while being machined, and are provided with necessary appliances for guiding, supporting, setting, and gaging the tools in such a manner that all the work produced in the same jig or fixture will be alike in all respects, even with the employment of more or less unskilled labor. When using the expression "alike," it implies, of course, simply that the pieces will be near enough alike for the purposes for which the work being machined is intended. Thus, for certain classes of work, wider limits of variation will be permissible without affecting the proper use of the piece being machined, while in other cases, the limits of variation will be so small as to make the expression "perfectly alike" literally true.

Object of Jigs and Fixtures.

The main object of using jigs and fixtures is, of course, the reduction of the cost of machines or machine details being built or made in great number. This reduction of cost is obtained in consequence of the increased rapidity by which the machines may be built, and on account of the employment of cheaper labor, which is possible when using tools for interchangeable manufacturing. Another purpose, however, not less important, is the accuracy with which the work can be produced, making it possible to assemble the pieces produced in jigs without any great amount of work in the assembling department, thus also effecting a great saving in this respect.

The use of jigs and fixtures practically does away with the fitting, as this expression was understood in the old-time shop; it eliminates cut-and-try methods, and does away with the so-called patch work in the production of machinery. It makes it possible to have all the machines turned out in the shop according to the drawings, a thing which is rather difficult to accomplish if each individual machine in a large lot is built without reference to the other machines in the same lot.

The interchangeability obtained by the use of jigs and fixtures, makes it also an easy matter to quickly replace broken or worn-out parts without great additional cost and trouble. When machines are built on the individual plan, it is necessary to send somebody from the shop where the machine was built to the place where it is installed, in order to fit the part replacing the broken or worn-out piece, in place, and this would, in a great many cases, involve considerable extra expense, not to mention the delay and the difficulties occasioned thereby.

As previously mentioned, jigs and fixtures permit the employment of practically unskilled labor. There are a great many operations in the building of a machine, which, if each machine were built individually, without the use of special tools, would require the work of expert machinists and toolmakers. Special tools, in the form of jigs and fixtures, permit equally good, or, in some cases, even better results to be obtained by a much cheaper class of labor, provided the jigs and fixtures are properly designed and correctly made. Another possibility for saving, particularly in the case of drill and boring jigs, provided with guide bushings in the same plane, is met with in the fact that such jigs are particularly adapted to be used in multiple-spindle drills, thereby still more increasing the rapidity with which the work may be produced, and at the same time making the machine extremely productive, so as to reduce the shop cost of this machine to a minimum. In shops where a great amount of duplicate parts are made, containing a number of drilled holes, multiple spindle drills, of complicated design, which may be rather expensive as regards first cost, are really cheaper, by far, than ordinary simple drill presses.

Another point of advantage which has been gained by the use of jigs and fixtures, and which should not be lost sight of in the enumeration of the points in favor of building machinery by the use of special tools, is that the details of a machine that has been provided with a complete equipment of accurate and durable jigs and fixtures, can all be finished simultaneously in different departments of a large factory, without inconvenience, thus making it possible to assemble the machine at once after receiving the parts from the different departments; and there is no need of waiting for the completion of one part into which another is required to fit, before making this latter part. This gain in time means a great deal to a manufacturing concern in cases where the orders are coming in with great rapidity, so as to require the utmost speed in production. This rapidity was entirely impossible under the old-time system of machinery building, when each part had to be made in the order in which it went on the finished machine and each consecutive part had to be lined up with each one of the previously made and assembled details. Brackets, bearings, etc., had to be drilled in place, often with ratchet drills, which of course, was a slow and always inconvenient operation.

Difference between Jigs and Fixtures.

To exactly define the word "jig," as considered apart from the word "fixture," is rather difficult, as the difference between a jig and a fixture is oftentimes not very easy to decide. The word jig is frequently, although incorrectly, applied to any kind of a work-holding appliance used in the building of machinery, the same as, in some shops, the word fixture is applied to all kinds of special tools. As a general rule, however, we can say that a jig is a special tool, which, while it holds the work, or is held on the work, at the same time also contains guides for the respective tools to be used, while a fixture is only holding the work, while the cutting tools are performing the operation on the piece, without containing any special arrangements for guiding these tools. The fixture, therefore, must, itself, be securely held or fixed to the machine on which the operation is performed, hence the name. A fixture, however, may sometimes be provided with a number of gages and stops, although it does not contain any special devices for the guiding of the tools.

The definitions given, in a general way, would therefore define jigs as special tools used particularly in drilling and boring operations, while fixtures, in particular, would be those special tools used on milling machines, and in some cases, on planers, shapers, and slotting machines. Special tools used on the lathe may be either of the nature of jigs or fixtures, and sometimes the special tool is actually a combination of both, in which case the expression drilling fixture, boring fixture, etc., is in place.

Fundamental Principles of Jig Design.

Before entering upon a discussion of the minor details of the design of jigs and fixtures, we will briefly outline the fundamental principles of jig and fixture design. Whenever a special tool is made up for a component part of the machine, it is almost always required that a corresponding jig

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* The following articles on the subject of jigs and fixtures have previously been published in MACHINERY: Milling Fixtures, November and December, 1905, January and February, 1906; Drill Jigs, November and December, 1906, January, 1907.

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is made up for the place on the machine, or other part, where the first-mentioned detail is placed. It is, of course, absolutely necessary that these two jigs be perfectly alike, as to the location of guides and gage points. In order to get the holes and guides in the two jigs in perfect alignment, it is advisable, and almost always attended with less cost, and with a gain in time, to transfer the holes or the gage points from the first jig made, to the other. In many instances, it is possible to use the same jig for both parts. Instances where the one or the other of these principles is applicable will be shown later in the detailed descriptions of drill and boring jigs. There are also cases where it is not advisable to make up two jigs, one for each of the two parts, which are to fit together. It may be that it is impossible to properly locate the jig on one of the parts to be drilled, or it may be that if the jig were made, it would be so complicated that it would not be economical. Under such conditions the component part, itself, may be used as a jig, and the respective holes or slots in this part used as guides for the tools when machining the machine detail into which it fits. Guide bushings for the drills and boring bars may then be placed in the holes in the component part itself. In many cases, drilling and boring operations are also being done, to great advantage, by using the brackets and bearings already assembled and fastened onto the machine body as guides.

One of the most important questions to be decided before making a jig is to what extent it is permissible to expend money on a special tool for the operation required. In many cases, it is possible to get a highly efficient tool by making it more complicated and more expensive, whereas a less efficient tool may be produced at very small expense. To decide which of these two types of jigs and fixtures should be designed in each individual case depends entirely on the circumstances. In any well managed shop there should be a careful comparison of the present cost of carrying out a certain operation, the expected cost of carrying out the same operation with an efficient tool, and the cost of building that tool itself. Unless this is done, it is likely that the shop is burdened with a great amount of special tools and fixtures which, while they may be very useful for the production of the parts for which they are intended, actually involve a loss. It is readily seen how foolish it is to make up an expensive jig and fixture for a machine or a part of a machine, that would only have to be duplicated a few times. In some cases, of course, there may be a gain in using special devices in order to get extremely good and accurate results.

Regarding the design of the jig, the most important requirements are that good facilities are provided for locating the work, and that the piece to be machined may be easily inserted and quickly taken out of the jig, so that no unnecessary time is wasted in placing the work in position on the machine performing the work. In some cases, a longer time is required for locating and binding the piece to be worked upon, in place, than is required for the actual machine operation itself. In all such cases the machine performing the work is actually idle the greater part of the time, and, added to the loss of the operator's time, is the increased expense for shop cost, incurred by such a condition. For this reason, the question of locating and binding the work in place quickly, and at the same time accurately, should be carefully studied by the designer before any attempt to design the tool is made. In choosing the locating surface or points of the piece or part, consideration must be given to the facilities of locating the corresponding part of the machine in a similar manner. It is, of course, highly important that this be done, as otherwise, although the jigs may be alike, as far as their guiding appliances are concerned, there may be no facility for locating the corresponding part in the same manner as the one already drilled, and while the holes drilled thus may coincide, other surfaces also required to coincide may be considerably out of line. For this reason, one of the main principles of location is that two component parts of the machine should be located from corresponding points and surfaces.

If possible, special arrangements should be made in the design of the jig so that it is impossible to insert the piece in any but the correct way. Mistakes are often made on this account in shops where a great deal of cheap help is used, pieces being placed in jigs upside down, or in some way other than the correct one, and work that has been previously machined and a great deal of time spent on, is entirely spoiled. Therefore, whenever possible, a jig should be made "fool-proof."

When the work to be machined varies in shape and size, as for instance in the case of rough castings, it is necessary to have at least some of the locating points adjustable, and placed so that they can be easily reached for adjustment, but, at the same time, so fastened that they are, to a certain extent, positive. In the following installments different kinds of adjustable locating points will be described in detail. The strapping or clamping arrangements should be as simple as possible, without sacrificing effectiveness, and the strength of the clamps should be such as to not only hold the piece firmly in place, but to take the strain of the cutting tools also without springing or "giving."

When designing the jig, the direction in which the strain of the tools or cutters act upon the work should always be considered, and the clamps so placed that they will have the highest degree of strength to resist the pressure of the cut.

A cardinal principle in the application of clamps to a jig or fixture is that they should be convenient for the operator, quickly operated, and when detached from the work still connected with the jig or fixture itself, so as to prevent the operator from losing them, or, at least, from losing time hunting for them. Many a time, looking for lost straps, clamps, screws, etc., causes more delay in shops than the extra cost sometimes incurred in designing a jig or fixture somewhat more complicated, in order to make the binding arrangement an integral part of the fixture itself. Great complication in the clamping arrangements, however, is not advisable. Usually clamping arrangements of this kind work very well when the fixture is new, but as the various parts become worn, complicated arrangements are more liable to get out of order and the extra cost incurred in repairing often outweighs the temporary gain in quickness of operation.

Some of the principles mentioned may seem contradictory, and in fact, they are. There is, therefore, all the more reason to refer to the fact that the judgment of the designer is, in every case, the most important point in the design of jigs and fixtures. Definite rules for all cases could not be given. General principles can be studied, but the efficiency of the individual tool will depend entirely upon the judgment of the tool designer in applying the general principles of tool design to the case in hand.

When designing the jig or fixture, the locating and bearing points for the work, and the location of the clamps must also be so selected that there is as little liability as possible of springing the piece or jig, or both, out of shape, when applying the clamps. Either the one or the other part being sprung, will, of course, cause incorrect results when the piece is taken out of the jig, as it will then spring back into its natural position, and its surfaces will be out of alignment with the holes drilled or the faces milled. The clamps or straps should, therefore, in as far as it is possible, be so placed that they are exactly opposite some bearing point or surface on the work.

The designer must use his judgment in regard to the amount of metal put into the jig or fixture. It is desirable to make these tools as light as possible in order that they may be easily handled, be of smaller size, and cost less in regard to the amount of material used for their making, but, at the same time, it is poor economy to sacrifice anything of the rigidity and stiffness of the tool, as this is one of the main considerations for efficient results. On large-sized jigs and fixtures, it is possible to core out the metal in a number of places, without decreasing, in the least, the strength of the jig itself. The corners of jigs and fixtures should always be well rounded, and all burrs and sharp edges filed off, so as to make them convenient and pleasant for handling. Smaller jigs should also be made with handles in proper places, so that they may be held in position while working, if it be a drilling jig, and also for convenience in moving the jig about.

Boring jigs and drill jigs should always be provided with feet on all sides which are opposite the holes for the bushings.

or other provisions for guiding the tools, so that the jig can be placed square on the table of the machine. These feet also greatly facilitate the making of the jig, making it much easier to lay out and plane the different finished surfaces. On the sides of the jig, where no feet are required, if the body is made from a casting, it is of advantage to have small lugs, projecting out, for bearing surfaces when laying out and planing. While jigs are most commonly provided with four feet on each side, in some cases it is sufficient to provide the tool with only three feet, but care should be taken in either case that all bushings and places where pressure will be applied to the tool are placed inside of the geometrical figure obtained by connecting, by lines, the points of location for the feet.

While it may seem that three feet are preferable to use, because the jig will then always obtain a bearing on all the three feet, which it would not with four feet, if the table of the machine were not absolutely plane, it is not quite safe to use the smaller number of supports, because a chip or some other object is liable to come under one foot, and throw the jig and the piece out of line, without this being noticed by the operator. If the same thing happens to a jig with four feet, it will rock, and invariably cause the operator to notice the defect. If the table is out of true, this defect, too, will be noticed for the same reasons.

One mistake, quite frequently made, is giving too little clearance between the piece to be machined and the walls or sides of the jig used for it. Plenty of clearance should always be allowed, particularly when rough castings are being drilled or machined in the jigs; besides, those surfaces in the jig which do not actually bear upon the work, are likely to be made up with some slight variation from the dimensions on the drawing, particularly in a cast iron jig, and allowance ought to be made for such differences as well.

In regard to the locating points, it ought to be remarked that, in all instances, these should be visible to the operator when placing the work in position, so that he may be enabled to see that the work really is in its right place. At times the construction of the piece to be worked upon may prevent a full view of the locating points. In such a case a cored or drilled hole in the jig, near the locating seat, will enable a view of same, so that the operator may either see that the work rests upon the locating point, or, if the work be very particular, so that he can get a feeler or thickness gage between the work and the locating surface, to make sure that he has got the work in its correct position. Another point that should not be overlooked is that jigs and fixtures should be designed with a view to making them easily cleaned from the chips, and provision should also be made so that the chips, as far as possible, may fall out of the jig and not accumulate on or about the locating points, where they are liable to throw the work out of its correct position, and consequently spoil the piece.

The principles so far referred to have all been in relation to the holding of the work in the jig, and the general design of the jig for producing accurate work. Provisions, however, should also be made for clamping the jig or fixture to the table of the machine, in cases where it is necessary to have the tool fixed while in operation. Small drilling jigs, for instance, are not clamped to the table, but boring jigs, and milling and planing fixtures invariably have to be firmly secured to the machine on which they are employed. Usually plain lugs, projecting out in the same plane as the bottom of the jig, or lugs with a slot in them to fit the body of T-bolts, are the common means for clamping fixtures to the table. For boring jigs, it is unnecessary to provide more than three such clamping points, as a greater number is likely to cause some springing action in the fixture. Some springing effect is almost unavoidable, no matter how strong and heavy the jig is, but, by properly applying the clamps, it is possible to limit this springing to so small a limit as to permit it to be commercially disregarded.

When jigs are made, before they are used, they should always be tested so as to make sure that the guiding provisions are placed in the right relation to the locating points and in proper relation to each other.

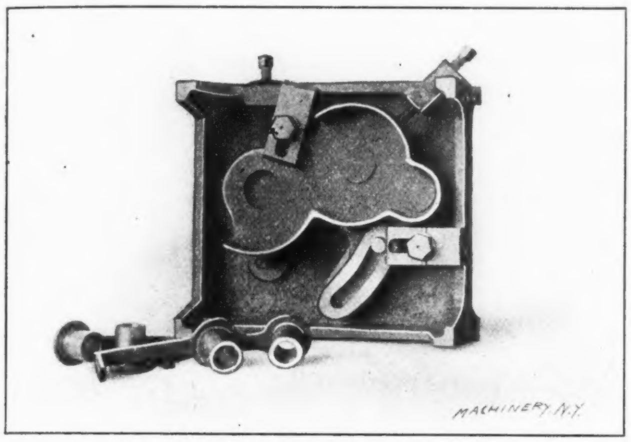

Fig. 1. Typical Open Drill Jig for Gear Guard.

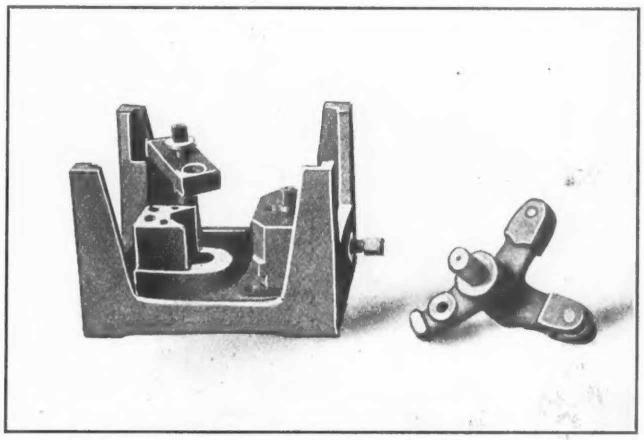

Fig. 2. Open Drill Jig, showing Commonly Used Design.

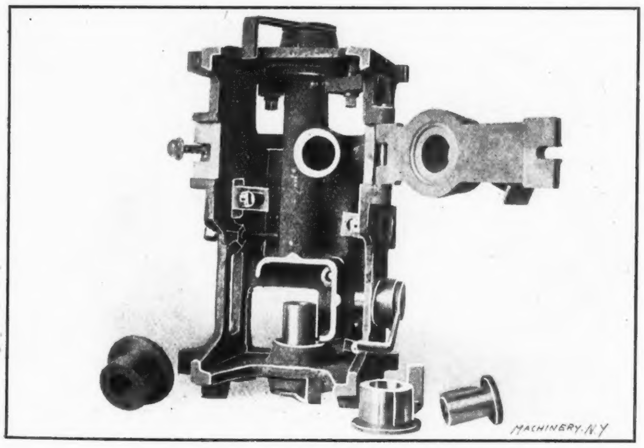

Fig. 3. Closed Drill Jig, showing Leaf Opened.

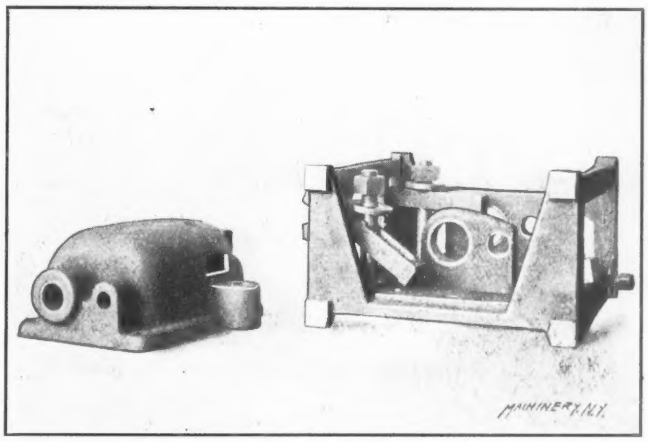

Fig. 4. Combination Drill and Boring Jig.

Summary of Principles of Jig Design.

Summarizing the principles referred to in the previous discussion, we may state the following rules as being the main points to be considered in the designing of jigs and fixtures.

1. Before planning the design of a tool, compare the cost of production of the work with present tools, with the expected cost of production, using the tool to be made, and see that the cost of building is not in excess of expected gain.
2. Before laying out the jig or fixture, settle upon the locating points and outline a clamping arrangement.
3. Make all clamping and binding provisions as quick acting as possible.
4. In selecting locating points, see that two component parts of a machine can be located from corresponding points and surfaces.
5. Make the jig "fool-proof," that is, arrange it so that the work cannot be inserted except in the correct way.
6. For rough castings, make some of the locating points adjustable.
7. Locate clamps so that they will be in the best position to resist the pressure of the cutting tool, when at work.
8. Make, if possible, all clamps integral parts of the jig or fixture.
9. Avoid complicated clamping arrangements, which are liable to wear or get out of order.

Classes of Jigs and Fixtures.

The two principal classes of jigs are drill jigs and boring jigs. Fixtures may be grouped as milling, planing, and splining fixtures, although there are a number of special fixtures which could not be classified under any special head.

Drill Jigs.

Drill jigs are intended exclusively for drilling, reaming, tapping and facing. Whenever these four operations are required on a piece of work, it is usually possible to provide the necessary arrangements for all these operations being performed in one and the same jig. Sometimes separate jigs are made for each one of those operations, but it is doubtless more convenient and cheaper to have one jig do for all, as the design of the jig will not be much more complicated. Although it may be possible to make a distinction between a number of different types of drill jigs, it is almost impossible

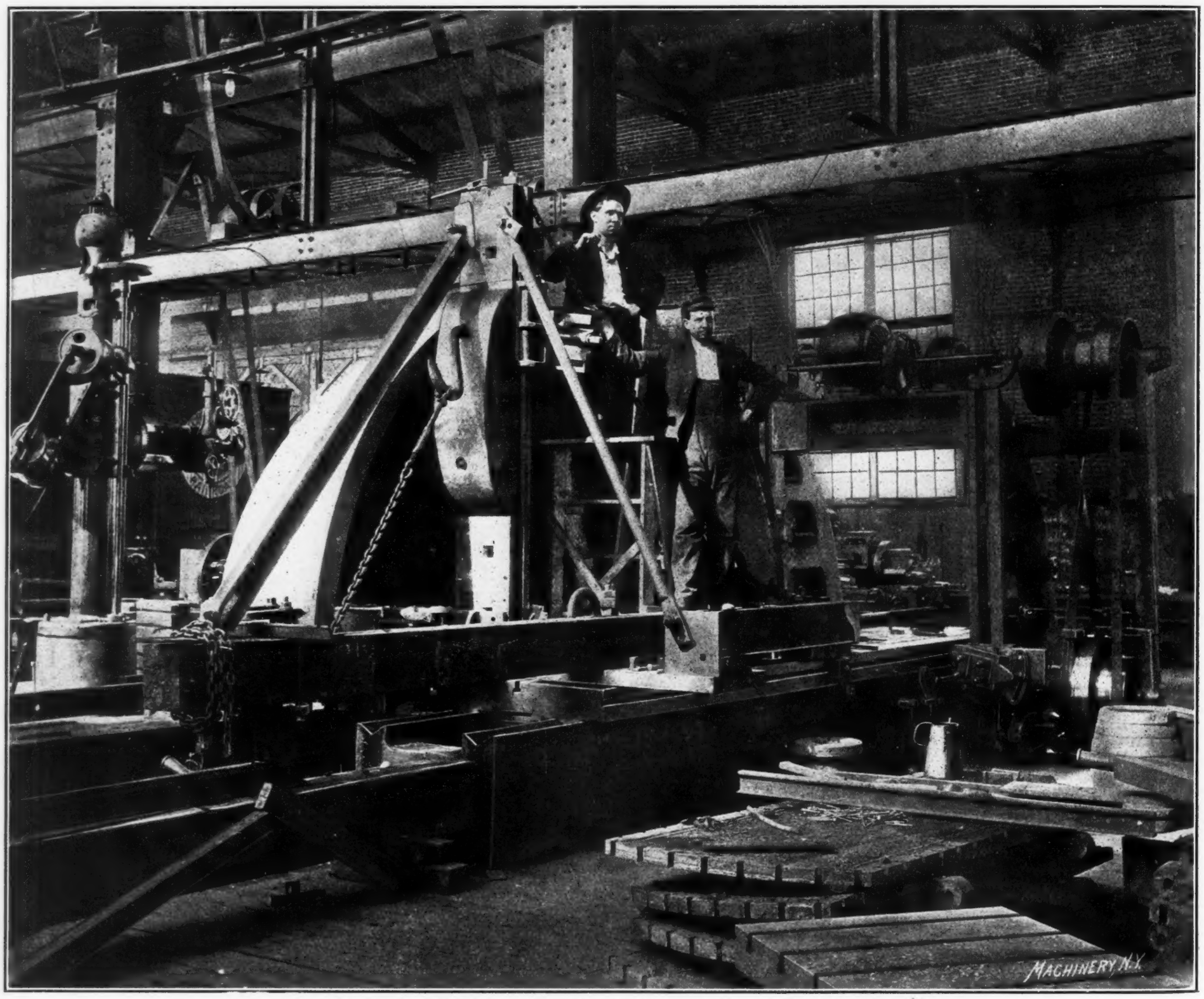

Fig. 1. View showing how the Large Casting Illustrated in Fig. 2 was planed on a 4-foot Planer.

10. Place all clamps as nearly opposite some bearing point of the work as possible, to avoid springing.
11. Cut out all unnecessary metal, making the tools as light as possible consistent with rigidity and stiffness.
12. Round all corners.
13. Provide handles wherever these will make the handling of the jig more convenient.
14. Provide feet, preferably four, opposite all surfaces containing guide bushings in drilling and boring jigs.
15. Place all bushings inside of the geometrical figure formed by connecting the points of location of the feet.
16. Provide abundant clearance, particularly for rough castings.
17. Make, if possible, all locating points visible to the operator when placing the work in position.
18. Provide holes or escapes for the chips.
19. Provide clamping lugs, located so as to prevent springing of the fixture, on all tools which must be held to the table of the machine while in use, and tongues for the slots in the tables in all milling and planing fixtures.
20. Before using in the shop, for commercial purposes, test all jigs as soon as made.

to define and to get proper names for the various classes, owing to the great variety of shapes of the work to be drilled. There are, however, two general types that are most commonly used, the difference between which is really very noticeable at sight. These types may be classified as open jigs and closed jigs, or box-jigs. Sometimes the open jigs are called clamping jigs, although it is difficult to see a good reason for this name. The open jigs usually have all the drill bushings in the same plane, parallel with one another, and are not provided with loose or removable walls or leaves, thereby making it possible to insert the piece to be drilled without any manipulation of the parts of the jig. These jigs are often of such a construction that they are applied to the work to be drilled, the jig being placed on the work, rather than the work being placed in the jig. The work is held to the jig (or the jig to the work) by straps, hook bolts or clamps. Figs. 1 and 2 show types of open drill jigs.

The closed drill jigs, or box-jigs, frequently resemble some form of a box, and are intended for pieces where the holes are to be drilled at various angles to one another. As a rule, the walls are solid with the face of the jig, and the piece to be drilled can be inserted only after a leaf or some leaves or covers have been swung out of the way. Sometimes it is necessary to remove a loose wall, which is held by screws and dowel pins, in order to locate the piece in the jig. The work in the closed drill jig is generally held in place by set-screws and sometimes by screw bushings, as well as by straps and hook bolts. Fig. 3 shows an example of a typical closed jig. Another type of closed jig is exemplified in a combination of drill and boring jigs, which are designed to serve both for drilling and boring operations.

Before designing a combination drill and boring jig, the relation between, and number of, the drilled and bored holes must be taken into consideration, and also the size of the piece to be machined. In case there is a great number of holes, it may be of advantage to have two or even more jigs for the same piece, because it makes it easier to design and make the jig, and very likely will give a better result. The holes drilled or bored in the first jig may be used as means for locating the piece in the jigs used later on. It is plain that combination drill and boring jigs are not very well adapted for pieces of large size. In Fig. 4 is shown a typical combination jig, where the bushings for guiding the drills are indicated in the bottom surface, the work upon which the operations are performed being shown at the left-hand side in the cut.

* * *

DIFFICULT PLANING JOB.

JOHN McLEOD.

The accompanying half-tone and line cut show how a difficult and unusual job was planed in the Payne & Jouberts shop, Birmingham, Ala. The work to be planed consisted of eight halves of four 14-foot sugar-pan domes, which were required to be planed where the faces of the two halves were fitted together. This planing job was carried out on a 4-foot Pond planer in the following manner: Two 24x24-inch angle

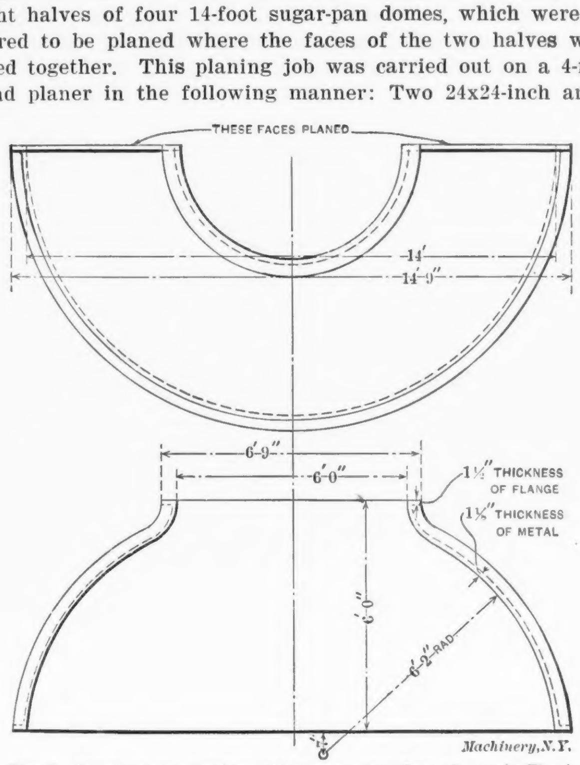

Fig. 2. Detail of the Casting which was planed as shown in Fig. 1.

plates were first bolted to the side of the planer bed, and the work then bolted to these angle plates, screw jacks supporting them at the other end, together with braces from the work to the planer housing. Then the cross-rail was taken off from its place, and securely bolted on end and braced on front and side, two foundry weights being clamped on the planer table for supports, as indicated in the half-tone, Fig. 1. In this manner the work was carried out to full satisfaction, and after the first half was finished, which, of course, took somewhat longer on account of the considerable rigging necessary, the balance of the work was finished at the rate of one-half of a dome in 12 hours.

THE LADY MANAGER AND THE FLY-WHEEL BID.

M. E. CANEK.

We read and hear much nowadays about the new woman and the wide swath she cuts in the business world. Personally, I think there is a good deal of nonsense written and talked about the matter. Most women are the same as their mothers and their grandmothers in preferring the quiet joys of housekeeping and domesticity to anything else. The hurly burly, trials and uncertainties of business life may be quite to the taste of a small percentage of women but not of the large majority. When a woman *does* take hold of a business job it is with deadly earnestness. She is "on the job" all the time, and woe to the unlucky chap who thinks that just because she is a woman he can play up monkeyshines instead of doing straight business. Now this story is not about a crooked business deal. On the contrary, it is about a gentleman general manager who pitted himself against a lady general manager in a straightforward business proposition, but who, nevertheless, felt very small after the deal had been consummated—entirely to the lady's liking. The incident occurred a few years ago in a thriving city not a thousand miles from New York.

Mr. Gray was the G. M. of the Snapshot Works, a concern noted for its enterprise, broad business policy and remarkable growth. Its handsome buildings, modern shop methods, fine business system and efficient selling department were the envy of would-be competitors the world over. Miss Brown was the G. M. of the Cog Works where cogs in all sorts of styles and shapes were whittled out of wood, brass, cast iron, steel or whatever material you wanted them made of. The "works" also made castings large and small, for all comers. I forgot to say that the cogs generally were on wheels. Some fastidious individuals may prefer to call them gears, and they are welcome to do so for all I care.

One morning late in September the engineer of the Snapshot Works discovered that the fly-wheel on the auxiliary engine used to run the lighting dynamo and to furnish power when part of the plant was working nights, had three spokes cracked. Though the wheel was in no immediate danger of breaking down, it was deemed advisable to get a new one as soon as possible. With characteristic energy and promptness, Mr. Gray issued calls to the large foundries of the city and the neighboring towns for bids on a new fly-wheel, fifteen feet diameter, weight about five tons, and *cast in one piece*. Now the only foundry in the home city that could or would handle the job was the Cog Works, and the G. M. of the Snapshot Works fully expected that this concern would get the job. The call for bids was more of a bluff to get a favorable price than anything else.

Well, a week passed and no bid was received from the Cog Works; in fact no acknowledgement was made of the letter asking for bids. Finally Mr. General Manager "called up" Miss General Manager, and in tones of some asperity demanded to know why no bid had been made on the fly-wheel.

"Is this Mr. Gray?"

"Yes."

"Well, Mr. Gray, we really haven't thought it worth while to make a bid on your fly-wheel."

"What! Don't you want the job?"

"I didn't say so. I simply said we didn't think it worth while to make a bid."

"How do you expect to get the job if you don't make a bid?"

"Can't you simply send the order over by a messenger, Mr. Gray?" (in sugary tones).

"Why, I tell you this job is going to be let to the lowest bidder."

"Yes, I know that, but aren't we just the same as the lowest bidder?"

"Why, how you talk. You haven't even made a bid, and you know that Jones of Pisgah and Smith of Ararat are just hot after such jobs."

"Yes, but they are not going to make your wheel. Now, Mr. Gray, have you thought of the fact that a fifteen-foot wheel is just a little too large to be carried on a railroad car?"

"Well, I'll be—er-er—excuse me, madam. Say, er-er—we'll send the order over this afternoon. Good-by."

"Good-by, Mr. Gray."

* * *

THE ARRANGEMENT OF FLOORING WITH REGARD TO SPRINKLERS.

The designs for the ordinary shop or mill are usually carried into material effect before the question of sprinklers is taken up. It may then be discovered that a different spacing of the timbers might have made a material change in the cost of the sprinkler system. Of course, prices will vary with localities, but taking a given case, an interesting comparison may be made. The fundamental rule of the insurance company was that no sprinklers should be called upon to serve a plain surface exceeding 100 square feet between timbers, and that for any less undivided space, unless a very small one, one sprinkler would be required. Fortunately the building was laid out on a 20-foot unit basis, and in the case of the roof, the timbers 20 feet long were spaced 10 feet on centers, keeping just within the limit, which called for two sprinklers for 200 square feet of space. But the main floors were planned for the spacing of timbers 20 feet long on 4-foot centers, leaving 3 feet between timbers, and establishing a plain surface under the floors measuring approximately 3 feet by 20 feet, or 60 square feet. As a result, five sprinklers were required instead of four in a given 20 feet square, an increase of 20 per cent in the sprinkler cost over what was required for the same total roof area. In this particular case, where the sprinkler equipment was installed on the basis of $3.00 per head, the cost for two floors was about $800.00 more than would have been necessary if it had been given an opportunity to serve the maximum area of 100 square feet. Here the expense of a framing arrangement to secure the minimum cost of sprinkler system per square foot would have increased the size of timbers through increasing their spacing on centers at a cost probably about equal to the saving in sprinklers. But in another building, in the same group, designed on different lines, the opportunity for a net saving was sufficiently manifest to attract attention, and suggest the necessity of giving thought to a matter not often considered.

* * *

Some interesting information regarding the over-supply of technically educated people in Germany, is furnished by the *Technik und Wirtschaft*, a supplement to the well-known *Zeitschrift des Vereines deutscher Ingenieure*. It appears that, at the present time, the German technical schools turn out a great many more well educated young men than there is actual demand for in the industries of the country. Even official opinions have been expressed in the matter, and the Bavarian press gives place to a statement from an official source, in which young men are discouraged, for the present, from entering into the technical field, as there is, at the present time, in the government service no opportunity for the great number of young men who have intended to enter into the service of the State Railways and the government Public Works department. Attention is also called to the comparatively small salaries received by technically educated men, caused, to a great extent, by the keen competition offered on account of the oversupply. In this connection, it may be of interest to mention the number of students at the ten highest German technical institutions. The total for the year 1907-1908 is 15,720, as compared with 15,453 in the previous year, the largest number of regular students being at the Hochschule at Munich, where there are 2,325, as compared with 2,291 regular students at the Berlin Hochschule.

A STUDY IN SPIRALS.

WALTER GRIBBEN.*

In cutting a spiral gear in a milling machine as ordinarily arranged, it is necessary to set the table to the helix angle in order that the sides of the cutter may not interfere, or drag in the cut. But the helix angle varies with the depth, being greatest at the top of the tooth, less at the pitch line, and still less at the bottom of the cut. In fact, if the cut were deep enough to reach all the way to the center of the piece being operated on, the helix angle would become zero, or parallel to

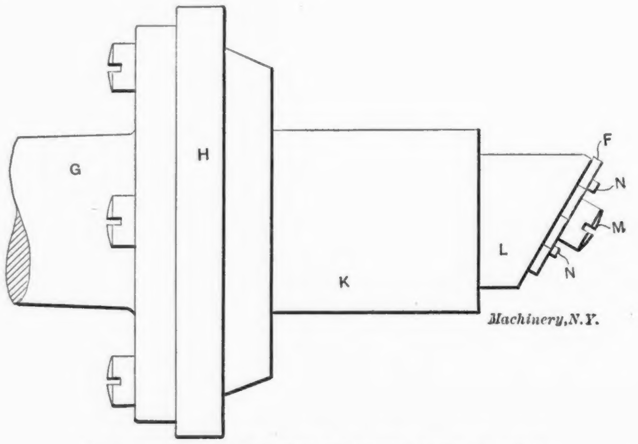

Fig. 1. Chuck for Mounting the Pieces shown in Fig. 2.

the center line. If the general run of mechanics were asked what would be the proper angle at which to set the table, I think they would say that the helix angle at the pitch line would be the one to determine the setting of the table, and I used to think so myself. This setting has the effect of making the width of the cut exactly right at the pitch line, but it does so at the expense of undercutting and weakening the teeth. For quite some time past I have thought that the helix angle at or near the bottom of the cut should be the one to set the table to in order to get a strong tooth, and to convince other mechanics of the correctness of this view I made the following experiments:

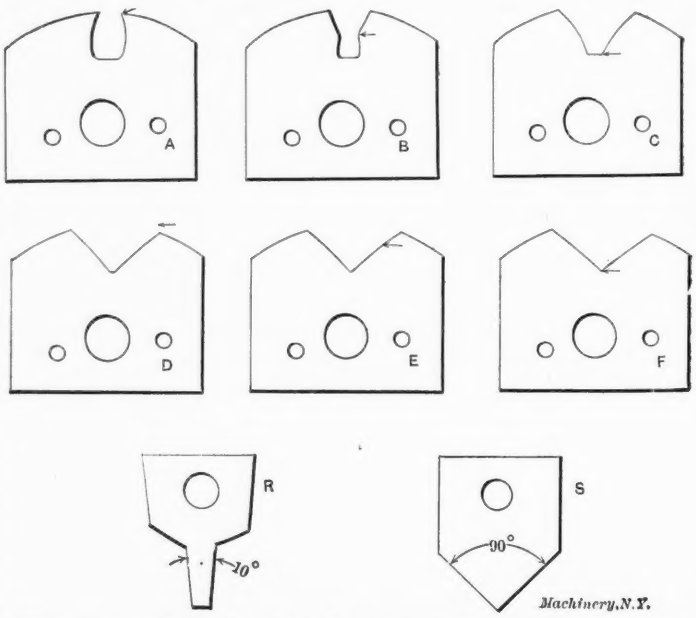

Fig. 2. Pieces milled on the Chuck, Fig. 1, with Fly-cutters R and S, showing the Effect of varying the Table Angle.

The piece *G*, Fig. 1, is a cast iron taper stem with a flange cast on, and fits in the dividing head of the milling machine. *H* is a brass chuck that was made for another job, and is fastened to *G* with four screws. *K* is a piece of 1$\frac{3}{8}$-inch round brass, with the ends faced true, while *L* is a piece of scrap brass with two faces machined at an angle of 30 degrees, one of these faces being tapped for the screw *M*, and also containing the two dowel pins *N*. *H*, *K* and *L* are sweated together with soft solder.

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The six pieces of sheet brass, *A*, *B*, *C*, *D*, *E* and *F*, Fig. 2, were drilled so they would fit onto the dowel pins in the 30-degree face of the improvised chuck, *F* being shown in place in the line cut, Fig. 1. These six pieces were placed in succession on this chuck and the curved edges of all turned to a diameter of 1.23 inch. I wanted to make a spiral cut in each of these six pieces, varying the setting of the table angle, and also the shape of the cutter, and compare the shape of the cut with that of the cutter that made it.

The lead used was 5.33 inches to one turn, and the depth of cut ¼ inch, both these elements being alike in all six cases. The pieces of sheet brass were intended to stand at right angles with the cut, but, of course, this was impossible, as the helix angle varied with the depth, so I made them stand at right angles with the helix at half depth. Assuming this helix angle to be 30 degrees ,we can find the diameter of the imaginary cylinder whose surface is at half the depth of the cut by multiplying the lead, 5.33 inches, by the tangent of 30 degrees, and dividing by 3.1416, which gives 0.98 inch. Adding 0.25 inch to this, we get 1.23 inch for the outside diameter, and also by subtracting 0.25 from 0.98 we get 0.73 inch for the diameter at the bottom of the cut.

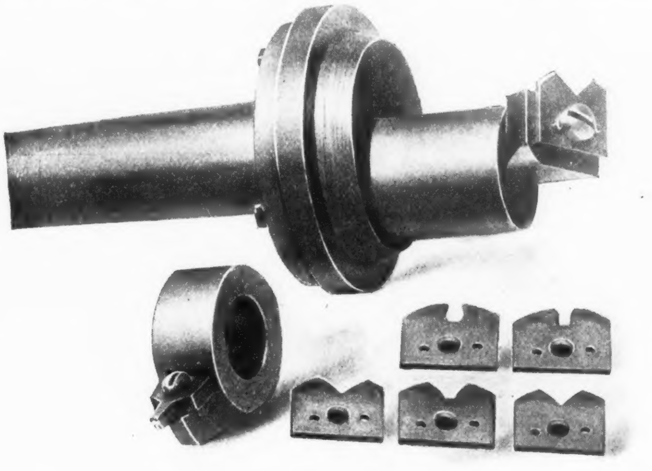


Fig. 3. Chuck, Fly-cutter, and Pieces milled in Experiments Described.

Knowing the outside diameter to be 1.23 inch, we multiply this by 3.1416 and divide by 5.33 to get the tangent of the helix angle at the top, which we find to be 35 degrees 56 minutes. In a similar manner we multiply the bottom diameter, 0.73, by 3.1416 and divide by 5.33 to get the tangent of the helix angle at bottom of cut, which we find to be 23 degrees 17 minutes.

The cutter used in this job was a fly-cutter, the holder being shown in the half-tone illustration Fig. 3, while its blades, *R* and *S*, are shown in the line illustration Fig. 2. *R* was used to cut *A*, *B* and *C*, while *S* was used to cut *D*, *E* and *F*. The table setting was nearly 36 degrees for *A* and *D*, 30 degrees for *B* and *E*, and about 23¼ degrees for *C* and *F*.

The shapes of the cuts show that the width of the cutter is accurately reproduced only at the particular depth where the helix angle is the same as the table setting, this point being shown by the arrow heads at the sides of the various cuts. The shapes of the cuts also show that the departure from the true form of the cutter due to faulty table setting is less in the case of the more flaring cutter *S* than in the case of cutter *R*, whose sides come nearer to being parallel.

This demonstrates to my mind that the table setting for a spiral gear should be the same as the helix angle at or near the bottom of the cut, because at this point the sides of the cutter come closer to parallelism, while at the top of the cut they are more flaring, and the table setting not being correct for the helix angle at this point would produce a comparatively slight error.

This also suggests a slight modification in selecting a cutter to do the job, as the tops of the teeth would be rounded off somewhat more than in the case of a spur gear cut with the same cutter. Therefore, it would be well to select a cutter for a greater number of teeth than the spiral gear formula $T = \frac{N}{\cos^3 a}$ calls for.

Setting the table for a less angle than that of the pitch line helix also has the effect of slightly increasing the width of the cut at the pitch line, but not to the extent that a comparison of *C* and *R* would seem to indicate, as in the experiments here described the depth of the cut was purposely made a very large percentage of the diameter in order to accentuate the errors due to faulty setting of the table, and if the table is to be set correct for the bottom of the cut, it might be well to consider the normal circular pitch as slightly greater than that rightfully belonging to the cutter in use, and size the blank accordingly. These experiments were entirely of a qualitative nature, and were only intended to guide the judgment of the designer and the man who puts the design in material form in cold metal.

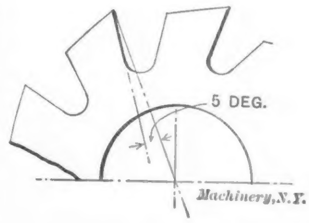
[Those not thoroughly familiar with universal milling machine use should carefully distinguish between the table angle and the helix angle produced by the gearing of the dividing head. The dividing head is geared to produce the required helix angle, measured on the pitch line the same as usual, of course. What Mr. Gribben advocates, in order to reduce interference, is simply setting the table to some helix angle between the pitch line and the dedendum or root circle rather than to the helix angle indicated by the pitch line. A point worth attention, also, is that the interference of a cutter increases with increase of diameter. Small cutters, therefore, tend to reproduce their outlines more accurately than large cutters, other things being equal.—Editor.]

* * *

NOTES ON HIGH-SPEED STEEL.

In a discussion regarding the manufacture and up-keep of milling cutters, at a meeting of the Institution of Mechanical Engineers, of Great Britain, one of the speakers called attention to one valuable property of high-speed steel, which he has not seen referred to, namely, that of withstanding shocks. In one of the railway shops in England, the output of the crank-turning lathes had been practically doubled by the use of high-speed steel tools. The forgings were never very accurate, there being perhaps ¼ inch to take off one side of the diameter, and 1½ inch off the other, and a tool suited to such wide variation was greatly appreciated. If the high-speed steel tool dug in, it did not break, as invariably happened with ordinary carbon steel.

Another speaker called attention to an important factor affecting the life of high-speed steel milling cutters. The teeth, besides being correctly relieved at the back should have a front rake of 5 degrees, as indicated in the accompanying cut. The number of teeth in milling cutters, particularly when made of high-speed steel, plays a very important part. A cutter made of this material with a large number of teeth, has a considerably shorter life than one with fewer but deeper teeth. In a certain case, two milling cutters, one with 16 teeth, and one with 32 teeth, had been made. The one with the coarser teeth, of helical shape, would finish an article with as good a finish as the one with the finer pitched teeth, but the cost of making the coarse-pitched cutter was 35 per cent less than the cost of making the one with the fine-pitched teeth, and the life of the coarse-pitched cutter was four or five times as long as that of the other.



* * *

Messrs. Gebrüder Sulzer, Winterthur, Switzerland, have recently devised a method of working internal combustion compressed air engines, which consists in one of the two ingredients of the charge required for burning, that is, either the air or the combustible gas alone, being introduced under pressure into the engine cylinder, and enclosed therein. The other ingredient is introduced in such a manner that the combustion process takes place during the whole of the time of the introduction, and is regulated according to the load. The temperature required for ignition is produced inside the working chamber, by any ignition device, without the fuel previously having been heated to its ignition temperature.

TAPER TAPS.—2.

ERIK OBERG.*

English Taper Pipe Taps.

English taper pipe taps constitute a special class of taper taps. These, most tap manufacturers in this country make exactly like the Briggs' standard pipe taps in regard to dimensions, the only difference being that the English taper pipe taps are provided with Whitworth form of thread, and with such a number of threads per inch as is called for by the standard for Whitworth standard gas and water pipe thread. It appears, however, that in England these taps are made with 1 inch taper per foot, instead of ¾ inch, and at least one firm in this country makes these taps with the taper according to this practice.

Pipe taps and taper taps in general are often made with the interrupted or Echols' thread shown in Fig. 6. A more

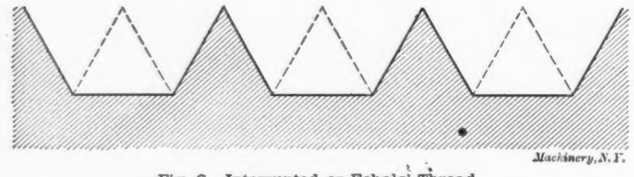


Fig. 6. Interrupted or Echols' Thread.

complete reference to this thread was made in an article entitled "Machine Taps," in the February, 1907, issue of MACHINERY. This form of thread is very well adapted for taper taps, and, in case of a very steep taper, is, in fact, almost essential if a smooth and perfect thread is to be cut. In hardening, pipe taps should be drawn to a somewhat higher temperature than ordinary hand taps of the same sizes. The correct temperature is about 470 degrees F.

Pipe Hobs.

Pipe hobs are used for sizing pipe dies, after the thread has been cut nearly to size either in a lathe or by a pipe tap. The length of the thread of a pipe hob is made longer than that of pipe taps, but there is not any very good reason why it should be so, excepting that it has become customary, and

TABLE V. DIMENSIONS OF PIPE HOBS.

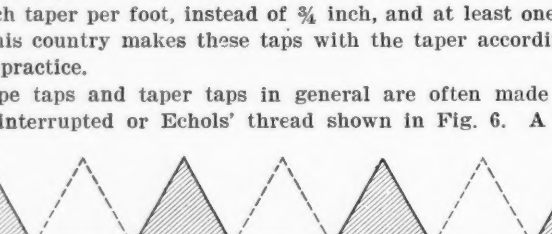


Fig. 7.

Nominal Size.	Actual Size.	Diameter at Large End.	Length of Shank.	Length of Thread	Length over all.	Diameter of Shank.	Size of Square.	Length of Square.
	A	B	C	D	E	F	G	H
1/8	0.445	0.539	2	3 3/16	5 3/16	3/8	5/16	1/2
1/4	0.573	0.667	2	3 3/8	5 3/8	1/2	3/8	5/8
3/8	0.719	0.813	2 1/16	3 1/2	5 9/16	5/8	7/16	3/4
1/2	0.885	0.979	2 1/16	3 5/8	5 11/16	13/16	5/8	7/8
3/4	1.104	1.198	2 1/8	3 7/8	6	1 1/16	13/16	1
1	1.363	1.457	2 1/8	4	6 1/8	1 5/16	1	1 1/8
1 1/4	1.721	1.815	2 3/16	4 1/8	6 5/16	1 5/8	1 1/4	1 1/4
1 1/2	1 955	2.049	2 3/16	4 1/4	6 7/16	1 7/8	1 7/16	1 3/8
2	2.460	2.554	2 1/4	4 1/2	6 3/4	2 3/8	1 13/16	1 1/2
2 1/2	2.963	3.057	2 5/16	4 11/16	7	2 7/8	2 3/16	1 5/8
3	3.620	3.714	2 3/8	4 7/8	7 1/4	3 9/16	2 5/8	1 3/4
3 1/2	4.062	4.156	2 7/16	5 1/16	7 1/2	3 11/16	2 13/16	1 3/4
4	4.485	4.579	2 1/2	5 1/4	7 3/4	3 3/4	2 13/16	1 7/8
4 1/2	5.000	5.094	2 9/16	5 3/8	7 15/16	3 13/16	2 7/8	1 7/8
5	5.565	5.659	2 5/8	5 1/2	8 1/8	3 7/8	2 15/16	2
6	6.620	6.714	2 3/4	5 3/4	8 1/2	4	3	2

established custom is as unyielding in tool making as in anything else. Outside of the longer length of thread, the only essential difference from the pipe tap is the number and the form of the flutes. These latter are cut with a 50-degree double-angle cutter, 25 degrees angle on each side, which is the same kind of a cutter as is used for ordinary straight hob taps. The number of the flutes may be approximately determined by the formula

$$8.5\,B = N$$

in which B equals the diameter at large end of thread of hob, and N equals the number of flutes.

With this formula, the width of each land is about 3/16 inch, and the width of the space or flute is the same amount. According to this formula the number of flutes for various sizes of pipe hobs are as follows:

TABLE VI. NUMBER OF FLUTES IN PIPE HOBS.

Size of Pipe Hob.	No. of Flutes.	Size of Pipe Hob.	No. of Flutes.
1/8	5	2	22
1/4	6	2 1/2	26
3/8	6	3	32
1/2	8	3 1/2	36
3/4	10	4	40
1	12	4 1/2	44
1 1/4	16	5	48
1 1/2	18	6	58

Dimensions of Pipe Hobs.

The dimensions for lengths and diameters of pipe hobs are given in Table V. The dimension A is given according to

TABLE VII. DIMENSIONS OF TAPER BOILER TAPS.

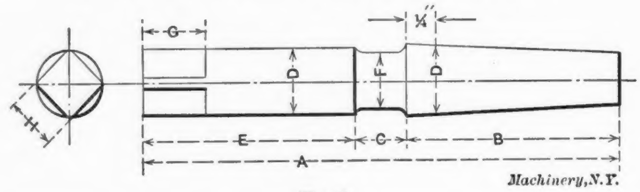


Fig. 8.

Diameter of Tap and Shank.	Total Length.	Length of Thread.	Length of Neck.	Length of Shank.	Diameter of Neck.	Length of Square	Size of Square.
D	A	B	C	E	F	G	H
1/2	4 1/4	2 1/4	1/2	1 1/2	11/32	1/2	3/8
9/16	4 7/16	2 5/16	1/2	1 5/8	13/32	9/16	7/16
5/8	4 5/8	2 3/8	1/2	1 3/4	15/32	5/8	15/32
11/16	4 13/16	2 3/8	9/16	1 7/8	17/32	11/16	1/2
3/4	5	2 7/16	9/16	2	19/32	3/4	9/16
13/16	5 3/16	2 1/2	9/16	2 1/8	21/32	13/16	5/8
7/8	5 3/8	2 9/16	9/16	2 1/4	23/32	7/8	11/16
15/16	5 9/16	2 9/16	5/8	2 3/8	25/32	15/16	11/16
1	5 3/4	2 5/8	5/8	2 1/2	27/32	1	3/4
1 1/16	5 15/16	2 11/16	5/8	2 5/8	29/32	1 1/16	13/16
1 1/8	6 1/8	2 3/4	5/8	2 3/4	31/32	1 1/8	7/8
1 3/16	6 5/16	2 3/4	11/16	2 7/8	1 1/32	1 3/16	7/8
1 1/4	6 1/2	2 13/16	11/16	3	1 3/32	1 1/4	15/16
1 5/16	6 11/16	2 7/8	11/16	3 1/8	1 5/32	1 5/16	1
1 3/8	6 7/8	2 15/16	11/16	3 1/4	1 7/32	1 3/8	1 1/16
1 7/16	7 1/16	2 15/16	3/4	3 3/8	1 9/32	1 7/16	1 1/16
1 1/2	7 1/4	3	3/4	3 1/2	1 11/32	1 1/2	1 1/8
1 5/8	7 5/8	3 1/8	3/4	3 3/4	1 15/32	1 1/2	1 1/4
1 3/4	8	3 3/16	13/16	4	1 19/32	1 1/2	1 5/16
1 7/8	8 3/8	3 5/16	13/16	4 1/4	1 23/32	1 1/2	1 7/16
2	8 3/4	3 3/8	7/8	4 1/2	1 27/32	1 1/2	1 1/2

the established standard of the manufacturers of taps. This is the essential diameter and is located 1½ inch from the large end of the thread of the hob. The limit of error for the location of this diameter is the same as the limit for the location of the size line of pipe taps which was stated in the March issue, and the gaging is done in the same manner. It is evident that a separate set of ring gages are required, and that the length of the gage in this case always should be 1½ inch, the large diameter of the hole in the gage being diameter B in Fig. 7, and the small diameter the dimension A. The taper of pipe hobs is, of course, the regular pipe thread taper, ¾ inch per foot.

The more important dimensions in Table V are figured from the formulas:

$$C = \frac{N + 16}{8}, \qquad D = \frac{5\sqrt{N} + 11}{4},$$

$F = A - 1/16$, for pipe sizes up to and including 3 inches,

$$F = \frac{N}{8} + 3\tfrac{1}{4}, \text{ for } 3\tfrac{1}{2}\text{-inch pipe sizes and larger.}$$

* Associate Editor of MACHINERY.

In these formulas:
A = size of hob 1½ inch from the large end of the thread,
N = nominal size of hob (pipe size),
C = length of shank,
D = length of thread, and
F = diameter of shank.

Relief.

Pipe hobs, being provided with a taper thread, must be relieved both in the angle and on the top of the thread. In this respect they differ from straight thread hobs, which are not relieved at all, except on the top of the thread of the short chamfer at the point.

Taper Boiler Taps.

Taper boiler taps, as the name indicates, are used in steam boiler work, and, like the pipe taps, are in this work used where a steam tight fit is desired. The taper of the taps is the same as the pipe tap taper, ¾ inch per foot. In regard to their construction there is nothing to say that has not already been said either in connection with pipe taps, or about taper taps in general. The size by which these taps are designated is located ¼ inch from the large end of the thread.

TABLE VIII. DIMENSIONS OF PATCH BOLT TAPS.

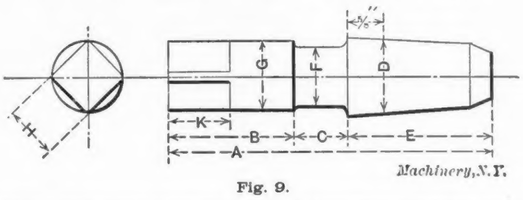


Fig. 9.

Diameter of Tap.	Total Length.	Length of Shank.	Length of Neck.	Length of Thread.	Diameter of Neck.	Diameter of Shank.	Size of Square.	Length of Square.
D	A	B	C	E	F	G	H	K
1/2	2 7/8	1 1/8	1/2	1 1/4	3/8	1/2	3/8	1/2
9/16	3	1 3/16	1/2	1 5/16	7/16	9/16	7/16	1/2
5/8	3 1/16	1 1/4	1/2	1 5/16	1/2	5/8	15/32	9/16
11/16	3 1/8	1 5/16	1/2	1 5/16	9/16	11/16	1/2	9/16
3/4	3 3/16	1 3/8	1/2	1 5/16	5/8	3/4	9/16	5/8
13/16	3 1/4	1 7/16	1/2	1 5/16	11/16	13/16	5/8	5/8
7/8	3 3/8	1 1/2	1/2	1 3/8	3/4	7/8	21/32	11/16
15/16	3 7/16	1 9/16	1/2	1 3/8	13/16	15/16	11/16	11/16
1	3 1/2	1 5/8	1/2	1 3/8	7/8	1	3/4	3/4
1 1/16	3 9/16	1 11/16	1/2	1 3/8	15/16	1 1/16	13/16	3/4
1 1/8	3 5/8	1 3/4	1/2	1 3/8	1	1 1/8	27/32	13/16
1 3/16	3 3/4	1 13/16	1/2	1 7/16	1 1/16	1 3/16	7/8	13/16
1 1/4	3 13/16	1 7/8	1/2	1 7/16	1 1/8	1 1/4	15/16	7/8
1 5/16	3 7/8	1 15/16	1/2	1 7/16	1 3/16	1 5/16	1	7/8
1 3/8	3 15/16	2	1/2	1 7/16	1 1/4	1 3/8	1 1/32	15/16
1 7/16	4	2 1/16	1/2	1 7/16	1 5/16	1 7/16	1 1/16	15/16
1 1/2	4 1/16	2 1/8	1/2	1 7/16	1 3/8	1 1/2	1 1/8	1

The permissible limits of error in regard to the location of the size line are the same as for pipe taps.

In Table VII dimensions are given for taper boiler taps. The most important of these are approximately figured from the following formulas:

$A = 3D + 2\frac{3}{4}$ inches. $E = 2D + \frac{1}{2}$ inch.

$B = \frac{3D}{4} + 1\frac{7}{8}$ inch. $C = \frac{D}{4} + \frac{3}{8}$ inch.

In these formulas:
A = total length of tap,
B = length of thread,
C = length of neck,
D = diameter of tap, measured ¼ inch from the large end of the thread.

These taps are provided with four flutes up to 1½ inch diameter, and with five flutes for sizes from 1⅝ to 2 inches. If made in sizes larger than 2 inches, six flutes should be given to the tap. Boiler taps are always provided with twelve sharp V-threads per inch, irrespective of the diameter of the tap.

Patch Bolt Taps.

Patch bolt taps are practically only a modified form of taper boiler taps. The taper is the same, but the threaded portion as well as the total length is shorter than the corresponding lengths of a taper boiler tap. The nominal size is measured ⅝ inch from the large end of the thread. These taps are used for purposes similar to the taper boiler taps, in boiler construction.

The dimensions for patch bolt taps are given in Table VIII. The essential dimensions are approximately figured from the formulas:

$A = 1\ 3/16\ D + 2\ 5/16$ inches, $B = D + \frac{5}{8}$ inch,
$E = 3/16\ D + 1\ 3/16$ inch, $F = D - \frac{1}{8}$ inch.

TABLE IX. DIMENSIONS OF MUD OR WASHOUT TAPS.

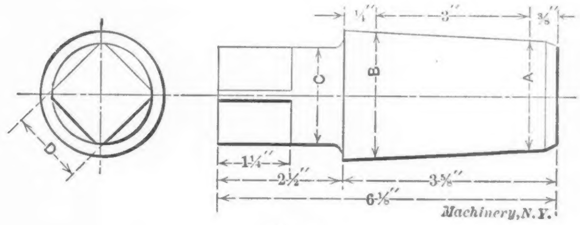


Fig. 10.

Number of Tap.	Diameter at Small End.	Diameter at Large End.	Diameter of Shank.	Size of Square.
	A	B	C	D
0	1 7/16	1 3/4	1 1/2	1 1/8
1	1 3/4	2 1/16	1 7/8	1 3/8
2	2 1/16	2 3/8	2	1 1/2
3	2 3/8	2 11/16	2	1 1/2
4	2 11/16	3	2	1 1/2
5	3	3 5/16	2	1 1/2

TABLE X. DIMENSIONS OF BLACKSMITHS' TAPER TAPS.

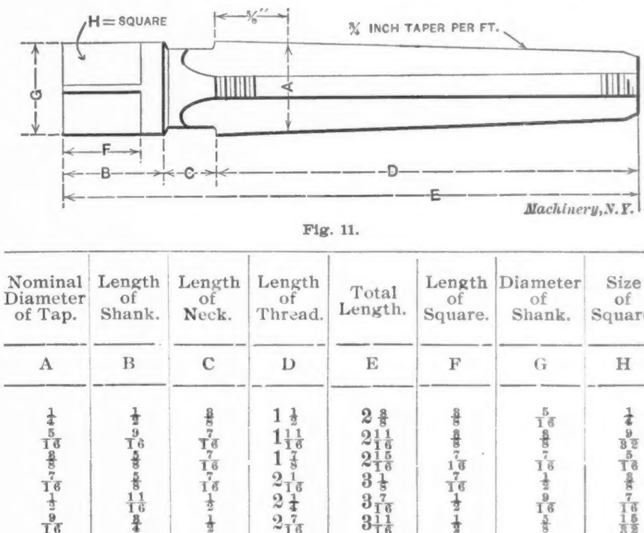


Fig. 11.

Nominal Diameter of Tap.	Length of Shank.	Length of Neck.	Length of Thread.	Total Length.	Length of Square.	Diameter of Shank.	Size of Square.
A	B	C	D	E	F	G	H
1/4	1/2	3/8	1 1/2	2 3/8	3/8	5/16	1/4
5/16	9/16	7/16	1 11/16	2 11/16	3/8	3/8	9/32
3/8	5/8	7/16	1 7/8	2 15/16	7/16	7/16	5/16
7/16	5/8	7/16	2 1/16	3 1/8	7/16	1/2	3/8
1/2	11/16	1/2	2 1/4	3 7/16	1/2	9/16	7/16
9/16	3/4	1/2	2 7/16	3 11/16	1/2	5/8	15/32
5/8	13/16	1/2	2 5/8	3 15/16	9/16	11/16	1/2
11/16	13/16	1/2	2 13/16	4 1/8	9/16	3/4	9/16
3/4	7/8	9/16	3	4 7/16	5/8	13/16	5/8
13/16	15/16	9/16	3 3/16	4 11/16	5/8	7/8	11/16
7/8	1	9/16	3 3/8	4 15/16	11/16	15/16	11/16
15/16	1	5/8	3 9/16	5 3/16	11/16	1	3/4
1	1 1/16	5/8	3 3/4	5 7/16	3/4	1 1/16	13/16
1 1/8	1 3/16	11/16	4 1/8	6	13/16	1 3/16	7/8
1 1/4	1 1/4	11/16	4 1/2	6 7/16	7/8	1 5/16	1
1 3/8	1 3/8	3/4	4 7/8	7	15/16	1 7/16	1 1/16
1 1/2	1 7/16	3/4	5 1/4	7 7/16	1	1 9/16	1 3/16

In these formulas,
D = diameter of tap (measured ⅝ inch from the large end of the thread),
A = total length of tap,
B = length of shank,
E = length of thread, and
F = diameter of neck.

The diameter of the shank equals the nominal diameter of the tap.

Patch bolt taps are always provided with twelve threads per inch, V form, irrespective of diameter. All sizes are fluted with four flutes up to 1½ inch diameter. Patch bolt taps are not manufactured in larger sizes.

Mud and Washout Taps.

Mud and washout taps are used in boiler work the same as the taps previously referred to. These taps are sometimes referred to as "arch pipe taps," but the former name is by far the most common. They are made in six sizes, usually known by the numbers as stated in Table IX. These taps taper 1¼ inch per foot and have twelve sharp V-threads per inch. The dimensions, as given in Table IX, conform in all essential details with the practice of the manufacturers of these taps. Number 0 tap is provided with five flutes, No. 1 with six, No. 2 with seven, and the remaining ones with eight flutes.

Blacksmiths' Taper Taps.

We have but one more class of taper taps generally manufactured, the blacksmith's taper tap. This tap has a long taper thread, and a very short shank, only sufficiently long for a square and a collar to prevent the tap wrench from slipping from the square down upon the body of the tap. The taper of the thread is ¾ inch per foot, and the size by which the tap is known is measured ⅝ inch from the large end of the thread. These taps are generally made with the standard number of V-threads per inch corresponding to their nominal diameter. The sizes given in Table X are the sizes generally made; these sizes all have four flutes.

TABLE XI. LENGTH AND DIAMETERS OF DRILL POINTS IN COMBINED PIPE TAPS AND DRILLS.

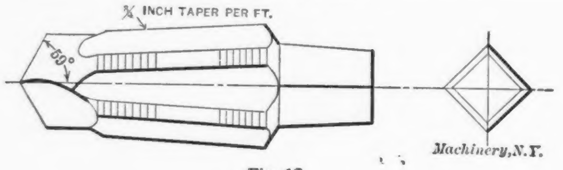


Fig. 12.

Pipe Tap Size.	Length of Drill Point.	Diameter of Drill.	Pipe Tap Size.	Length of Drill Point.	Diameter of Drill.
$\frac{1}{8}$	$\frac{7}{8}$	$\frac{11}{32}$	1	$1\frac{1}{2}$	$1\frac{9}{64}$
$\frac{1}{4}$	1	$\frac{7}{16}$	$1\frac{1}{4}$	$1\frac{5}{8}$	$1\frac{1}{2}$
$\frac{3}{8}$	$1\frac{1}{8}$	$\frac{37}{64}$	$1\frac{1}{2}$	$1\frac{3}{4}$	$1\frac{23}{32}$
$\frac{1}{2}$	$1\frac{1}{4}$	$\frac{45}{64}$	2	$1\frac{7}{8}$	$2\frac{3}{16}$
$\frac{3}{4}$	$1\frac{3}{8}$	$\frac{29}{32}$	$2\frac{1}{2}$	2	$2\frac{5}{8}$

Pipe Taps and Drill Combined.

Pipe taps are sometimes provided with a drill point, as shown in Fig. 12, for drilling the hole previous to tapping. Instead of a square for a wrench, they are then usually provided with square taper shank for a taper drill socket. The dimensions of the shank must, of course, suit the requirements. The threaded portion is an exact duplicate of the threaded part of a pipe tap. The drill part has two flutes like a twist drill, and the point is ground to the same angle, 59 degrees with the center line, as are ordinary twist drills. The diameter and the length of the drill point are the only dimensions necessary to state in this connection.

* * *

Some interesting facts about alloys of silicon are reported in *Engineering*. Alloys containing from 5 to 15 per cent of silicon can, like nickel, be forged cold, but not when at a red heat. When the percentage of silicon exceeds 22, the hardness of the alloy increases. A regulus with 25 per cent of silicon cleaves like mica in sheets, and alloys containing more than 50 per cent of silicon can be powdered. It is interesting that an alloy containing 20 per cent of silicon is much harder when slowly cooled than when suddenly chilled.

* * *

The growth of the motor car industry, in which aluminum is now extensively used, has greatly increased the use of this metal. The present output of aluminum is between 15,000 and 20,000 tons yearly. In America there are at present 56 installations using aluminum wire for electric power transmission purposes, some of these being in connection with schemes of considerable magnitude and importance. This application of the metal has not been followed up in Europe, where doubts exist in the minds of engineers as to its suitability for outside work involving long-continued exposure to a humid atmosphere.

GRINDING AND GRINDING MACHINES.*

CARL OLSON.

The development of the grinding machine has made rapid progress during the last few years, and the process of grinding is more and more recognized as having both economical and technical advantages, as compared with the old methods of obtaining finish. This is especially true regarding plain cylindrical grinding, and this is due chiefly to the fact that the machines for this kind of grinding are easier to build, and in general more efficient than machines for other kinds of grinding.

It has often been claimed, by people who have had long and thorough experience in regard to this subject, and whose testimony, therefore, must be considered as having weight, that time can be saved in finishing a cylindrical piece of work by taking a roughing cut with an ordinary cutting tool, leaving about from 0.008 to 0.010 inch, and grinding off this amount, instead of taking a second cut in the lathe, and finishing the piece by filing. One great advantage of the grinding machine is the closer finish that can be obtained.

In some special cases, when the steel to be finished is so hard that it cannot be cut by means of a cutting tool, the grinding machine has to take the place of the lathe entirely. Of course, the work in this case cannot be done so cheaply as in the case of ordinary kinds of steel, but still it can be done with fair economy. As the piece is taken entirely rough and put up in the grinding machine, there is, considering the errors in casting, about ⅛ inch up to 3/16 inch on the diameter, that has to be ground off. When so large an amount of metal has to be removed by grinding, another problem than that dealt with when only 0.008 to 0.010 inch has to be ground off presents itself. The writer has recently designed three special grinding machines, two for external and one for internal work, all for very heavy duty. Herein are given a few of the conclusions arrived at while designing these machines. Being, as mentioned, mostly used for heavy grinding, the machines may differ some from the common light grinding machines, but the principles remain, in general, the same.

Any machine tool must, of course, be designed heavy enough not only to take all the strains produced by the action of the cutting tool or wheel, but to prevent all, or nearly all, vibration and chattering of the machine itself. This is true of the grinding machine more than of any other machine tool. Rigidity is a very important factor in the efficiency of the machine, both in regard to heavy grinding and grinding for very exact sizes and high finish.

Influence of Vibrations on Action of Grinding Machines.

The grinding wheel rotating at a high speed tends to jar its bearing and supports. Vibrations of this kind would result in an oscillating motion of the grinding wheel perpendicular to its own axis of rotation and along the line connecting the center of work with the center of the wheel. The frequency of these vibrations depends entirely upon the weight of the oscillating parts. The cause of the vibrations is that the center of gravity of the rotating parts, grinding wheel, shaft, pulley, etc., is not entirely the same as the center line of rotation. This is partly due to the uneven structure of the material. It is very plain to everybody, that the oscillating grinding wheel cannot cut to its full capacity. The length of the oscillations might not be large, perhaps only one-thousandth of an inch or a fraction thereof, but the cut will be just so much deeper one moment than the next following. Only at one moment, when the wheel is furthest in, will it cut to its full capacity.

It is very important, in order to secure nice running of the wheel, to have the belts in good order, and to have the boxes closely adjusted, even though they run a trifle warm. Because of the high speed of the shaft, the boxes ought to be made with ring-oiling devices. This would allow a closer adjustment, and secure a better running of shaft. However, as far as the writer knows, there are no grinding machines

* The following articles on this and kindred subjects have previously been published in MACHINERY: A Talk on the Disk Grinder, June, 1904; The Grinding of Thread Gages, October, 1904; The Cost of Grinding, October, 1906; Grinding Crank-shafts, March, 1907; and Grinding a Large Crank-shaft, April, 1907.

on the market equipped with ring-oiling boxes. The slides should, for the same reason as the boxes, be adjusted closely, even though they slide hard.

Speed of Grinding Wheels.

The peripheral speed of the grinding wheel should be approximately from 5,000 to 5,500 feet per minute. There are occasionally cases when higher speed is desirable, but with higher speed there is danger of the wheel breaking. The wheel should, however, never be run slower than 5,000 feet per minute, because it becomes less efficient at slower speeds.

Below will be found a table which gives the number of revolutions per minute for specified diameters of wheels to cause them to run at the respective periphery rates of 5,000 and 6,000 feet per minute.

TABLE OF SPEEDS OF EMERY WHEELS.

Diameter of Wheel, inches.	R. P. M. for Surface speed of 5,000 feet.	R. P. M. for Surface Speed of 6,000 feet.
1	19,099	22,918
2	9,549	11,459
4	4,775	5,730
6	3,183	3,820
8	2,387	2,865
10	1,910	2,292
12	1,592	1,910
14	1,364	1,637
16	1,194	1,432
18	1,061	1,273
20	955	1,146
24	796	955
30	637	764

Experience has shown that for grinding work with fairly large diameter, better results are obtained by using a comparatively small wheel than by using one with too large a diameter. The explanation of this fact is that the wheel of smaller diameter clears itself faster from the work, while the larger one has a larger contact surface, and, therefore, the specific pressure between wheel and work becomes reduced, and the metal removed by the wheel stays too long a time between the wheel and work, and prevents the particles of the wheel from cutting properly into the work. The peripheral speed must, however, be the same for the smaller wheel as for the larger one.

Surface Speed of Work.

The proper surface speed of the work varies somewhat with the material and kind of work to be done. The grinding machine builders recommend 15 to 30 feet as a good average speed range for ordinary kind of work. For cast iron this can be slightly increased. The writer has had experience in grinding a very tough and hard steel (manganese steel), and has found the right surface speed in this special case to be as low as 6 to 8 feet a minute for rough grinding. For finishing grinding, the speed should be somewhat higher than for rough grinding. For delicate work the speed should be slow, because the work could easily be damaged by forced grinding.

As a general rule, for determining the surface speed for a certain kind of material, one can say that a brittle material, as cast iron, takes a high speed, while a tough and hard material, as the best tool steel, takes a slow speed. For grinding close to size and for high finish, the depth of the cut must be small, and higher surface speed can consequently be used.

Many of the grinding machines on the market are built so as to have the work revolving on two dead centers. This is done more for the sake of being able to obtain accuracy than for the sake of increasing the cutting efficiency of the machine.

Traverse Speed of Grinding Wheel.

The traverse speed of the grinding wheel should for ordinary grinding be three-fourths of the width of the wheel, that is, for one revolution of the work the wheel should travel three-fourths of the width of the face. If the wheel be traversed slower, the new cut is overlapping the old one more than necessary, and too large a part of the wheel is idle. It is, however, necessary that the new cut overlaps the old one with about one-fourth of the width of the face, because the edges of the face easily become rounded off, and, if the travel be too rapid, the result is an uneven surface.

The capacity of the wheel, within certain limits, of course, is proportional to the width of the face. A certain specific pressure between wheel and work is required for the highest cutting capacity. A wider wheel requires consequently a larger total pressure. But many of the machines now on the market are not rigid nor heavy enough to stand the pressure needed for a fairly wide wheel, cutting at full load, without vibration and chatter. The grinding machines on the market have not, in the writer's opinion, yet reached their full capacity. Wider wheels should be used, and the machines be designed and built heavier in order to take the load of the cutting wheel, without perceptible vibration of the machine.

For the final smooth finish, a slower traverse speed should be used, especially if the face of the wheel is not kept a perfectly straight line. A smoother surface is obtained by using a slower traverse speed. The part of the wheel which is overlapping, while theoretically it does not cut, still wears away the unevennesses left from the first cut, and, by this, to some extent polishes the surfaces.

While grinding a plain cylindrical piece of work, the grinding wheel should not be allowed to travel too far past the ends of the piece before reversing; it is only waste of time. The wheel should be reversed when three-fourths of its width is past the end of the work.

Depth of Cut.

The depth of the cut to be taken depends upon the material, kind of wheel, and of work done. It should be deep enough to permit the wheel to do its utmost. This is, of course, true only about pieces that are rigid enough to stand a heavy cut. The grinding operator himself will have to determine the depth of cut for each individual case, judging it by the prevailing conditions of work, machine, and wheel.

When the piece to be ground, owing to the hardness of the material, cannot be roughly finished by a cutting tool before being placed in the grinding machine for the final finish, there is often up to 3/16 inch on the diameter to be removed by grinding. Employing the same principle as when the piece is previously to the grinding operation roughly turned in a lathe, the work should first be put up in a machine equipped with a coarse and wide grinding wheel. A wheel of this kind is capable of removing stock rapidly. The piece should be finished to within about 0.005 inch of the finish diameter in this machine, and then moved to a machine equipped with a finer grain wheel, and the final finish given to it. A fairly high grade of economy is thus obtained.

The Grinding Wheel.

For heavy grinding, the alundum wheel is the best for removing stock rapidly. The carborundum wheel will give a smoother finish, and is to be recommended for the large majority of other classes of grinding. Emery is less abrasive, but gives a higher polish. Most grinding wheel manufacturers recommend their medium grade, *M*.

TABLE OF GRADE OF WHEEL TO USE FOR DIFFERENT MATERIALS.

Material.		Grit No.	Grade.
Soft steel	Ordinary shafts ...	24 to 60	Medium.
	Steel tubing or very light shafts	24 to 60	Two or three grades softer than medium.
Tool steel or cast iron. ...		24 to 60	Medium or one grade softer.
Internal grinding		30 to 36	Medium or several grades softer.

The question as to what is the very best wheel for finishing any particular piece cannot be definitely answered. Above will be found a table, giving wheels which can with advantage be used in the cases mentioned. This table is recommended by one of the largest grinding machine manufacturers.

Grit No. 24 may be too coarse for any but rough classes of work, but if mixed with No. 36 it gives a fair result. No. 30 used separately is capable of a very fair commercial finish, but if mixed with No. 46 will give as fine a finish as is

desired by the majority of the grinding machine users, and at the same time it retains the rapid cutting capacity. Nos. 46 and 60 are as fine as is necessary for almost any manufacture, although finer than these are used by some concerns who require a very high gloss finish.

A satisfactory grinding wheel is an important factor in the production of good work. In machine grinding, it is desirable, in order that the cut may be constant, and give the least possible pressure and heat, to break away the particles of the wheel after they have become dulled by the act of grinding. It is the faculty of yielding to or resisting the breaking out of the particles which is called grade. The wheel from which the particles can be easily broken out is called soft, and the one that retains its particles longer is called hard. It is evident that the longer the particles are retained the duller they

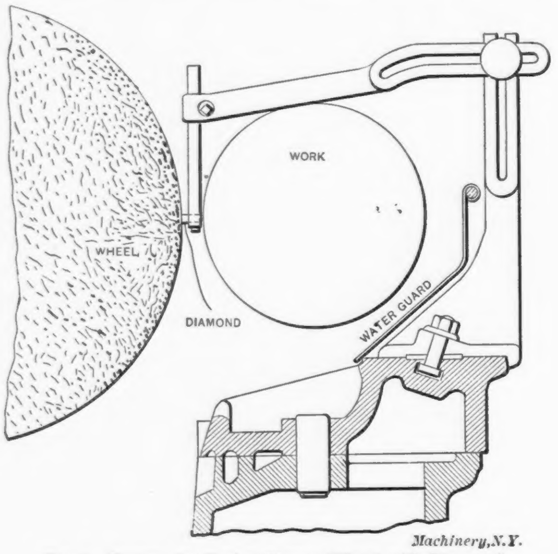


Fig. 1. Fixture for Truing Emery Wheel with Diamond.

will become, and the more pressure will be required to make the wheel cut. Retaining the particles too long causes what is familiarly known as glazing. A wheel should cut with the least possible pressure, to effect which it must always be sharp. This is maintained by the breaking out of particles. Therefore, a wheel of proper grade cutting at a given speed of the work possesses "sizing power," or ability to reduce its size uniformly without breaking away its own particles too rapidly; obviously if the work is revolved at a higher speed, the particles will be torn away too fast, and the wheel will lose its sizing power.

The properties of toughness and hardness of the material to be ground has a retarding influence on the grinding because it makes the material stick to or clog the wheel. The ground-off material, instead of being thrown away from the wheel by the centrifugal force, gets in between the particles of the grinding wheel. It is self-evident that this has a greatly retarding effect on the cutting quality of the wheel. A brittle material, on the contrary, does not have the tendency of clogging the wheel, but the stock ground off is immediately thrown away from the wheel, leaving the particles free to cut without the retarding action of undue friction, and generation of more than the due amount of heat. If we take into consideration only these properties of the material to be ground, the tough or leady material requires a soft wheel, because the particles must break away fast enough to prevent the wheel from being clogged. In this case, the particles do not wear enough to become dull, but must break away before this. When grinding a brittle or hard material, on the contrary, the wheel is less liable to be clogged, the particles do not need to break away so soon, and, therefore, a harder wheel should be used. However, the wheel must not be so hard that the particles get too dull and become inefficient as cutting agents before they break away.

Importance of Wheel Running True.

In order to obtain the full efficiency of the grinding wheel, it must be run perfectly true; that is, cut evenly all the way around. The grinding wheel detects its own errors. A slight difference in the sparks indicates that the wheel is out of true. The eccentric wheel has about the same kind of action as the one which is vibrating because of too weak supports. Furthermore, the edge of the grinding wheel should be kept perfectly straight. If the edge be curved, however slightly, a curved cut will be the consequence. Many grinding machines give inefficient results because the edge of the wheel is not kept in a true straight line. The operator seldom appreciates the great importance of this, and, therefore, the foreman should watch the man closely in regard to this point.

The best tool for truing the wheel is the diamond, but, this being rather expensive for shops where not very much grinding is done, the usual emery wheel dresser can be used with good advantage. In truing the wheel, the dressing tool should be kept stationary and rigidly supported, and the wheel should be traversed back and forth, until the true edge is obtained. Fig. 1 shows a fixture and arrangement for wheel truing with a diamond.

Wet and Dry External Grinding.

Nearly all plain cylindrical grinding is now done wet. There are many reasons why the wet method is to be preferred to the dry. Because of the friction between the grinding wheel particles and the work, as well as between the cut-off material before it leaves the wheel and the work, more or less heat is generated. If this heat is not carried away, the work will be burned. Besides, the edge of the grinding wheel would be highly heated, but the center would still remain comparatively cool, the outer part would expand and there would be danger of the wheel breaking. It is found that the water has a softening effect upon the wheel, therefore a harder wheel is required for wet grinding than for dry.

Machines with Two Grinding Wheels.

The grinding machines on the market are equipped with only one grinding wheel, but there is no reason why two grinding wheels cannot be employed to advantage. In this case one wheel is to operate on each side of the work. As both of the wheels are to throw the sparks and the water down, one of the wheels has to cut with the revolving of the work, that is, the peripheries of the wheel and the work are going downwards. This is, of course, not the ideal condition, but, when the work is revolving at a slow peripheral speed, there is not much difference in the cutting capacity of the two wheels.

It is self-evident that, when employing two wheels, one at each side of the work and right opposite each other, the traverse speed of the wheels must be twice as fast as in the case of only one wheel, or three-fourths of the width of the wheel for one-half revolution of the work. Otherwise one wheel will overlap the cut of the other.

The two machines for external grinding which the writer has recently designed, and of which one is in operation and one being built, have two wheels working according to the principle previously described, and the machine already in operation is giving entire satisfaction. Fig. 2 gives an idea of the arrangement used on one of these machines. The principal features of the design can be studied direct from the cut without any further comments.

One new feature of these machines is that each grinding wheel is driven independently by a motor. This motor is mounted above the wheel spindle, and is belted directly to same. Special attention has been paid to designing the support of the motor in order to prevent the vibrations of the motor from being transferred to the grinding wheel.

Internal Grinding.

The development of internal grinding is not, by far, so advanced as that of external grinding. To be sure, there are a few machines and fixtures on the market that are designed and built for the internal grinding of holes of various kinds, but the machines suffer from lack of rigidity, and some of the most conscientious grinding machine builders do not recommend them very highly, but admit their inefficiency for removing any comparatively large amount of stock. It has even gone so far that one man holding a prominent position with one of the largest grinding machine manufacturing concerns in the country has said, that in his opinion, the internal

grinding machine is a mistake from start to finish, and that it will never be made a success.

This state of affairs has not come about without good reason. As we already have seen, the rigidity of the arrangement for supporting the grinding wheel is a very important factor for all efficient grinding. But the internal grinding machine does not very well lend itself to the employment of any rigid and heavy fixtures, and the grinding wheel must necessarily be small, and therefore lacks the strength to stand a heavy cut. The designer, when designing the fixtures for internal grinding, has an entirely different problem to solve than when designing those for external grinding, where it is comparatively easy to obtain ample rigidity. The internal grinding wheel must be mounted at the end of a small spindle which projects past the bearing far enough to enable the wheel to reach past the end of the hole to be ground. Such a spindle rotating at a high speed is liable to vibrate, especially if a pressure be applied at the end of it, as is here the case.

Sometimes, however, it becomes absolutely necessary to grind, internally, even a comparatively large amount of stock.

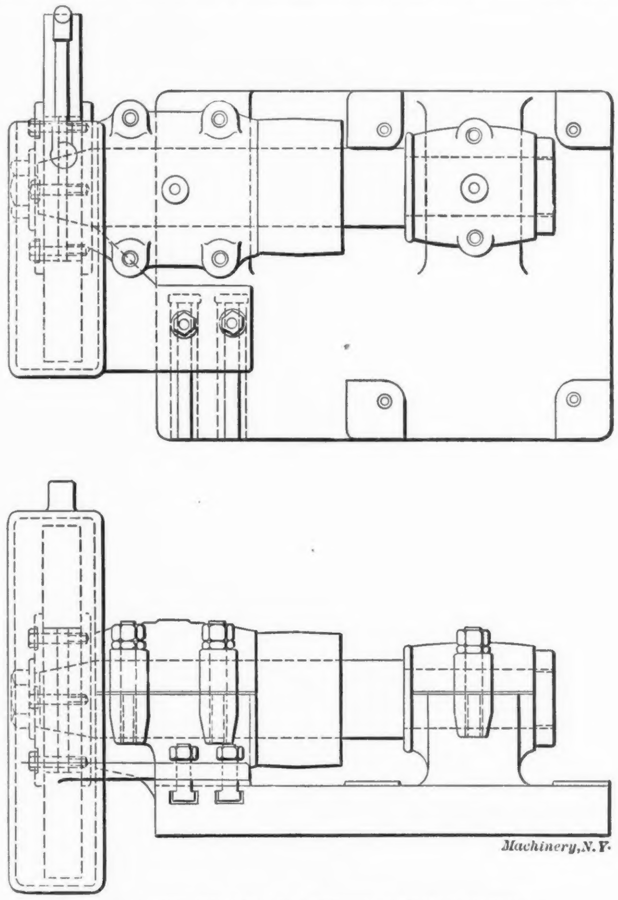


Fig. 2. Grinding Head for External Grinding Machine.

This is the case, when finishing manganese steel, this material being so hard that it cannot be cut by any kind of tool steel. Take the case of bores of manganese steel car wheels. As the grinding of the bores must be done without any stock having previously been removed from the rough casting, on the average, about one-eighth inch of metal must be ground off from the hole. All the errors in the cored hole, as eccentricity in reference to the circumference of the wheel, etc., must be corrected by grinding. A hole cored in a manganese steel casting is always comparatively much rougher than a hole cored in cast iron, and all this must be taken into consideration, when determining the amount of stock to leave for the grinding process.

The old method for finishing the bores of these wheels was to cast an ordinary steel bushing in the hole. This then was bored in the usual manner in a lathe or boring mill. But this method had several objectionable features, and, besides, it was too expensive.

Design of Fixtures for Internal Grinding.

The fixture used in the internal grinding machine designed for grinding these wheels is shown in Fig. 3. Internal grinding fixtures, generally have a long extension bearing, as shown in Fig. 4. This serves to support the spindle as near to the grinding wheel as possible; but the diameter at the root of this extension, that is, nearest to the box, cannot exceed the diameter of the grinding wheel.

The spindle, shown in Fig. 3, is made solid, and has the largest diameter possible for the size of the grinding wheel. An increased amount of rigidity and a greatly increased simplicity is gained by this design.

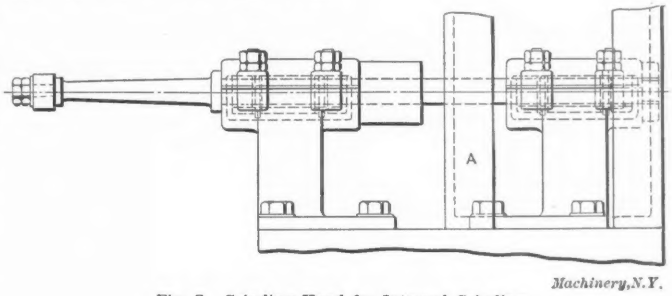


Fig. 3. Grinding Head for Internal Grinding.

When working, the grinding wheel produces, especially in dry grinding, very much dust. When inside a hole the dust cannot very easily get away, but whirls about in the hole. If the spindle has a bearing near to the grinding wheel, the dust will find its way into the journal. This drawback is entirely eliminated by having a large solid spindle without a bearing near to the grinding wheel.

As to the relation between the overhanging part of the spindle and the distance between centers of the boxes, there are many factors that come into consideration in regard to this relation, such as the design of the boxes, the diameter of the spindle, how close the spindle can be allowed to run in the boxes, etc. However, the distance between the centers of the boxes should be made as large as the general design conveniently permits.

The cut shows at *A* the support for the motor. This support is placed on the top of the top rest. The driving pulley is placed between the bearings, so that the support could be made as rigid as possible.

It was found by actual experience with these fixtures, that when the grinding wheel was taking a fairly heavy cut the spindle did not vibrate nearly so much as when the wheel was running idle. The springing quality of the spindle, and the pressure between work and wheel, made the wheel cut without any chattering worth mentioning.

Regarding the peripheral speed of the grinding wheel, what has already been said with reference to external grinding is equally applicable to internal grinding.

Because of the lighter fixtures the speed of the work should be slower than for external grinding. The writer has found the right cutting speed for manganese steel to be, for heavy grinding, about seven feet a minute. For the finishing, the speed can, with advantage, be somewhat higher. Because of the combined hardness and toughness of this steel, the cutting speed is exceptionally low in this case. Regarding the

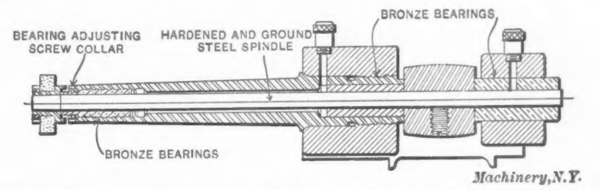


Fig. 4. Common Construction of Grinding Heads for Internal Grinding.

traverse speed of the wheel, it should travel three-fourths of its width for one revolution of the work, the same as for external grinding.

Wet and Dry Internal Grinding.

One point that has been much discussed in regard to internal grinding, is whether it shall be conducted wet or dry. Some grinding machine designers have advanced the opinion that it, by all means, must be done dry, but others claim the wet method to be superior. For light finishing grinding one method might be considered as good as the other, because so small an amount of heat is generated that there is no danger of burning the material or breaking the wheel. But, for

heavier grinding, a considerable amount of heat is generated, and it becomes necessary to carry it off by water. At least, such is the writer's own experience on this subject. At a test recently conducted to find out the actual difference between dry and wet internal grinding, it was found that the cutting quality of the grinding wheel was about the same in both cases, but, with a heavy feed and dry grinding, the work was highly heated, and the wheel broke after about half an hour's run, while, with wet grinding, the wheel stood the heavy cut continuously without breaking.

The water can be injected into the hole in a stream about one-sixteenth inch in diameter. In addition to carrying away the heat, the water serves to wash away the removed stock from the hole.

The writer conducted, a short time ago, a test on the above mentioned internal grinding machines, in order to find out and supply the sales department with a figure of the time required to grind the bores of a certain kind of manganese steel car wheels. Two different kinds of wheels were tested. The first one, a 20-inch diameter wheel, had a bore 2⅞ inches in diameter and 5⅞ inches long, and it was to be ground for a press fit. The second one, an 18-inch diameter wheel, had a bore 3¼ inches in diameter and 4½ inches long, and was also to be ground for a press fit. Four wheels of each kind were ground during the course of the test, and it was found that the actual time for the grinding operation, not including the time required for putting up the work in the machine, was, for the first kind of wheels 1 hour and 23 minutes for all four, and for the second kind, 1 hour and 9 minutes for four wheels. Considering that the bores of the wheels were not previously turned, but entirely rough, as the wheels were taken directly from the foundry, and considering the hardness and toughness of the steel, the results obtained were considered good. The time of putting up the work in the machine was about 6 to 8 minutes for each wheel. As the machines work automatically, one man is able to run three machines. Counting 8 minutes for the putting up of each wheel, the man is able to grind one wheel in 30 minutes of the first kind, and one wheel in 26 minutes of the second kind.

The work was revolved at a speed of 7.7 revolutions per minute. This makes a peripheral speed, for the first case, of 5.8 feet a minute, and for the second case, of 6.6 feet a minute. The grinding wheel used was a 2-inch diameter, 1-inch face, No. 46 grit, O grade alundum wheel. It was run at a speed of 4,750 feet a minute.

The traverse speed of the work was as high as 0.84 inch per revolution of work. This allowed the wheel to overlap the old cut by only 0.16 inch but, as the grinding wheel was trued very carefully, this was found to be all there was required for obtaining a nice smooth surface. The traverse feed was not slowed down, but remained the same while doing the final finishing, and a very satisfactory finished hole was obtained. The test was made throughout with wet grinding.

For heavy cylindrical grinding, that which I especially referred to, the width of the wheel used varies between 1½ and 2½ inches, regardless of the diameter. In some special cases narrower wheels than 1½ inch are used, but these special cases are exceptions to the general practice, and must be recognized as such by the machine builders and users. Although larger wheels are used, it is my opinion that the best range of diameters of wheels is between 12 and 18 inches. For how wide a wheel the grinding machine in the future can be designed, has yet to be decided; but, wider wheels and heavier machines point the direction of the road which the designer and machine builder should follow for the development of the grinding machine.

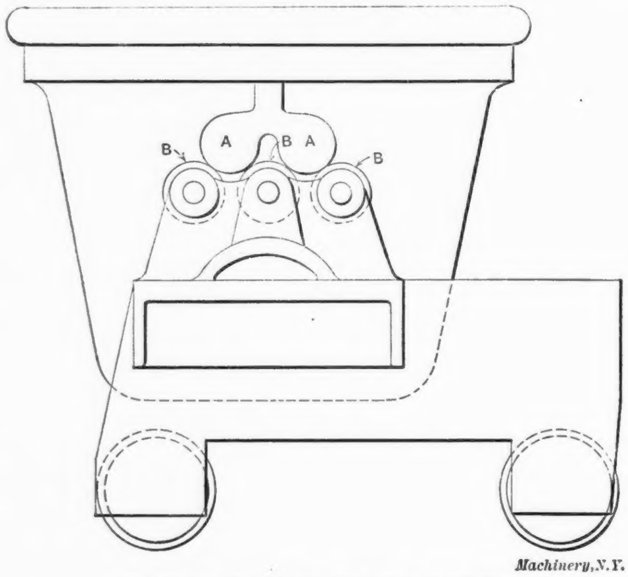
* * *

The output of the world's shipyards for the year 1907 was 1,930 vessels of over 100 tons displacement, with an aggregate of 3,099,299 tons. The tonnage of the vessels built in the United States amounted to 474,675 tons, which is 33,400 tons greater than the output for the previous year. Of the total tonnage of the vessels built in this country, considerably more than half was constructed for the Great Lakes.

ITEMS OF MECHANICAL INTEREST.

UNIQUE BEARING FOR END-TIPPING SLAG LADLE.

Another interesting application of roller bearings is shown in the diagrammatical sketch, herewith, of an end-tipping slag ladle made by the Dewhurst's Engineering Company, Ltd., Attercliffe Road, Sheffield, England. In this design double trunnions *A* are cast on each side of the ladle, and are located slightly above its center of gravity so that the ladle will right

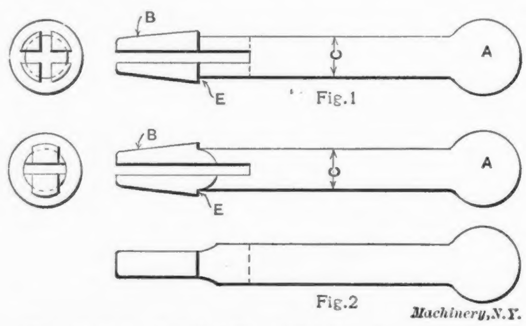


End-tipping Slag Ladle with Roller Bearings.

itself from any point to which it may be tipped. Roller bearings *B* are provided on the carriage on which these trunnions rest, and this greatly reduces the power required for tipping, as the trunnions roll easily along the surface of the rollers. The principle exhibited is a very interesting one, and shows how simple means may be adopted for solving a rather difficult problem of machine design, and indicates the possibility of the efficiency of the least elaborate devices which are not likely to get out of order, and which hardly need any attendance whatever.

SUBSTITUTE FOR COTTER PINS.

The accompanying cut shows an interesting little appliance, used instead of the common split cotter pin. The pin shown is manufactured by a Swedish firm, Aktiebolaget Bofors-Gullspang, Bofors, Sweden. Its simplicity and general usefulness of application seem to warrant that attention be called to it. As will be seen, the pin in Fig. 1 simply consists of a round piece of stock, provided with a ball-shaped head *A* at one end, and a tapering head *B*, at the other, the corner *E* being quite sharp. The pin is split, as shown, crosswise, so that when pushed into a hole, it will spring sufficiently to



Figs. 1 and 2. Showing Pins which take the Place of the Common Split Cotter Pin.

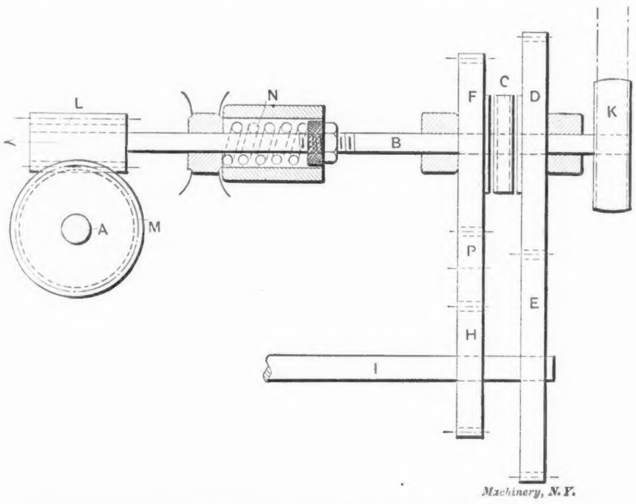
permit being pushed through, but as soon as part *B* has passed through the hole, it will spring out again, and on account of the sharp corner at *E*, it is not possible for the pin to slip out of the hole again, excepting if a special tool (a socket with a hole in it of the same diameter as the body *C* of the pin) is applied at the end to force the prongs together, so as to make the head small enough to enter the hole. These pins are also made by simply having one slot through them,

and then flatted on the two sides a trifle below the diameter of the central portion *C* of the pin, as shown in Fig. 2. In applying these pins, nothing is necessary but to put the tapered end into the hole, and gently press with the hand on the top of the head *A*, until the pin is in place.

DEVICE FOR ADJUSTING THE FEED OF A ROTATING CUTTING TOOL IN PROPORTION TO THE WORKING PRESSURE.

The *Zeitschrift für Werkzeugmaschinen und Werkzeuge*, shows, in its issue for December 5, 1907, an interesting mechanism for automatic adjustment of the feed in proportion to the working pressure on the cutting edges of a rotating cutting tool. The principle of the device is shown in the diagrammatical view in the accompanying cut. This device is intended to make it possible to automatically throw out the feed, when the pressure on the cutting edges of the tool becomes heavier than normal, and to completely reverse the feed in case this pressure still continues to be abnormally high when the feed is thrown out.

Referring to the cut, *A* represents the spindle of the machine to which the cutting tool, say a drill, is attached. This spindle is driven through worm gear *M* and worm *L* from the driving shaft *B*, which, in turn, receives its motion from the counter-shaft through the belt on pulley *K*. The driving shaft *B* is free to move in its axial direction, within certain limits. The clutch *C* is keyed to the shaft *B*, so that it will rotate and also move axially with the shaft. On each side of clutch *C* gears *D* and *F* are mounted on shaft *B*, in such a manner that they remain stationary in the axial direction. These gears are not keyed to the shaft *B*, but turn freely, and motion is imparted to them from clutch *C*, one of the gears being engaged at a time. The sides of gears *D* and *F*, which face toward the clutch *C*, are themselves provided with clutch teeth, so that the clutch can engage with either of the gears. The gear *D* in turn engages with gear *E*, on the feed-shaft *I*, so that if clutch *C* is driving gear *D*, motion will be imparted to the feed-shaft *I*, and the tool will be fed forward. If, again, the clutch disengages gear *D*, and



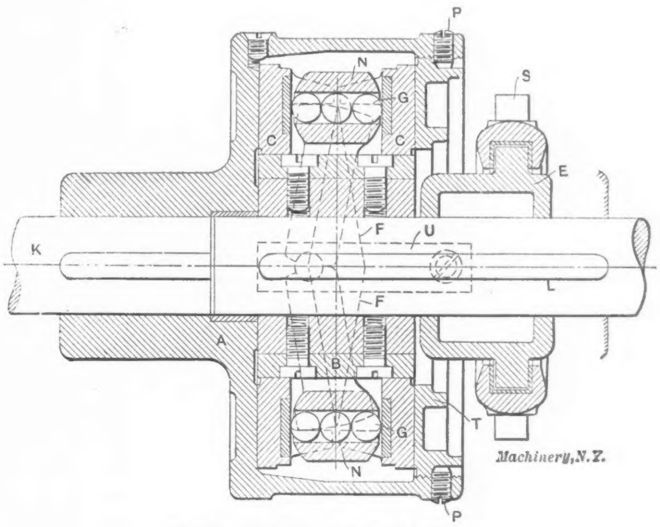
Diagrammatical View of Device for Automatically Adjusting Feed in Proportion to Pressure on Cutting Edge of Tool.

occupies a neutral position, no motion whatever will be imparted to the feed-shaft *I*. If, again, clutch *C* engages with the gear *F*, then the feed-shaft *I* will be driven through an intermediate gear *P* and gear *H*, thereby reversing the motion of feed-shaft *I*, as compared with the direction when receiving motion directly through gears *D* and *E*.

The engagement or disengagement of the clutch *C* with the clutches on gears *D* and *F* is accomplished as follows: Spring *N* is, through the nuts shown, adjusted to the proper tension, so that it will normally hold the driving shaft *B* in such a position that clutch *C* engages with the clutch on gear *D*, when, as we have seen, the feed shaft feeds forward. In case the load on the cutting edges of the tool should exceed the normal load, however, the worm-wheel will exert such a pressure on the teeth of the worm as to pull the worm in the direction of the arrow, shown at the end of the worm, thereby compressing the spring *N*, and pulling the clutch *C* out of engagement with the clutch on gear *D*. Clutch *C* then takes a central position and the feed is stopped. Should the resistance to the rotation of the cutting tool still continue to be strong enough to compress the spring still further, the clutch will enter into engagement with the clutch on gear *F*, in which case motion will be transmitted to the feed-screw *I* through the gears *P* and *H*, as mentioned before, which then reverses the feed motion.

HAEBERLIN FRICTION COUPLING.

The accompanying cut shows an interesting and ingenious friction coupling for transmitting power from one shaft to another, if these are situated in a straight line with one another. Of course, the design may be applied to almost any kind of a friction coupling, if suitably modified. If we assume that the shaft *K* is the driving shaft, and the shaft *L* the driven shaft, power is transmitted from the one to the other through the medium of rollers *G*. The construction is, briefly, as follows: The flanged sleeve *A* is keyed to the shaft *K*, but is independent of the shaft *L*. To the outside of this sleeve, a pulley, spur gear, or other means for trans-



Friction Coupling of Ingenious Design.

mitting power, may be attached. The action of the device, of course, is the same whether the shaft *K* or the shaft *L* is the driving shaft.

The driver *B* is attached to the shaft *L* and is also keyed to friction disks *C C*, so that if the friction disks are actuated by the power, and rotate, they will carry with them the driver *B* and the shaft *L*. The friction disks *C* rotate with the sleeve *B*, but are still free to move in a longitudinal direction. The opening of the sleeve *A* is closed at the right-hand end by the cover *T*, which is prevented from turning by the set-screws *P*. The threads on the cover permit a fine adjustment, so that the inside width of the sleeve, between the outside of rings *C*, can be adjusted within very small limits, and the transmission of power can thus be controlled.

The characteristic feature of this design is to be found in the simple and practical mechanism for producing pressure on the friction disks *C*, so that these will be carried around with the sleeve *A* and its cover *T*. This arrangement consists, in general, simply of two levers *N*, provided with hardened steel rollers *G*. When the mutual center line of these three rollers is parallel with the axis of the shaft, which is the case when the coupling is in the driving position, then the distance between the friction disks *C*, and also the pressure on the friction surfaces, are the greatest. When the levers *N*, by pulling out sleeve *E*, which is attached to the ring *S* for its operation, are pulled from the position shown, and brought into the position indicated by the center lines *F*, shown by the dotted lines, the center lines through the rollers *G* will form an acute angle with the axis of the shaft, and the pressure between the surfaces *C C* and the sleeve *A* or the cover is released. The link *u* combines the sleeve *E* with the levers *N*, which are operated through this connection. These friction couplings are made by Düsseldorfer Maschinenbau-Aktiengesellschaft, Düsseldorf-Grafenberg, Germany.

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We solicit communications from practical men on subjects pertaining to machinery, for which the necessary illustrations will be made at our expense. All copy must reach us by the 5th of the month preceding publication.

APRIL, 1908.

PAID CIRCULATION FOR MARCH, 1908, 22,507 COPIES.

MACHINERY is published in four editions. The practical work of the shop is thoroughly covered in the Shop Edition—$1.00 a year, comprising more than 430 reading pages and 36 Shop Operation Sheets, containing step-by-step illustrated directions for performing 36 different shop operations. The Engineering Edition—$2.00 a year, coated paper $2.50—contains all the matter in the Shop Edition, including Shop Operation Sheets, and about 250 pages a year of additional matter, which includes a review of mechanical literature, and forty-eight 6 x 9 data sheets filled with condensed data on machine design, engineering practice and shop work. The Foreign Edition, $3.00 a year, comprises the same matter as the Engineering. RAILWAY MACHINERY, $2.00 a year, is a special edition, including a variety of matter for railway shop work—same size as Engineering and same number of data sheets.

DIVIDENDS AND FOUL AIR.

If there is in the dictionary a stronger word of its kind than "asinine," we would like to use it to describe the mental caliber of those responsible for the heating and ventilating arrangements in some shops and drafting-rooms with which we are acquainted. In the absence of a stronger word, perhaps the one we have used will do. Good air and an equable temperature have come to be recognized as necessary to the proper accomplishment of physical or mental labor, and the neglect of these provisions is the exception rather than the rule; but there are still shops in which the proprietor handicaps his workmen and diminishes his own profits by the unsanitary condition of his plant.

We were reminded of this recently by a visit to a large drafting-room, connected with a plant the responsible heads of which are surely old enough to know better, and prosperous enough to act on their knowledge without even temporary financial embarrassment. The air was thick and heavy and foul, and listlessness and sluggishness were apparent everywhere in the faces and actions of the draftsmen. It would seem as though a single clear-eyed glance at the room and its occupants (assisted perhaps by an analytical sniff of the tainted atmosphere) would have been enough to show the proprietors on which side their bread was buttered.

* * *

AN ASPECT OF PATENT RIGHTS.

The daily newspapers recently gave considerable space to an alleged wonderful improvement in firearms, made by the son of a well-known inventor of rapid-fire guns. The invention is in the nature of an automatic valve placed transversely in the barrel near the muzzle, which is required to close immediately following the passing of the bullet so as to divert the gases to the atmosphere through small side openings. The object is to prevent the sudden expansion of the gases, and thus render the firing of the piece noiseless. The principle of action is somewhat similar to that of the gas engine muffler in breaking up and dispersing the gases, and so destroying the sharp reports of the explosions.

An examination of the patent specification (No. 880,386) discloses a curious fact. The invention is covered by a basic patent of twenty-three claims, but it is, as described and illustrated, practically inoperative. In fact, we very much doubt the practicability of the idea as outlined by the inventor—for one reason, because of the inertia of the necessary moving parts, but the patent has suggestive value and it may eventually lead to the solution of the problem. The field for following inventors is what we are concerned about.

The patent is basic, and no matter how ingeniously some really practical intercepting valve scheme for rendering firearms noiseless is worked out, its inventor is barred from its use by an impracticable invention which has been awarded basic claims. To say the least, this seems unfair to future genius. It is not quite just, that, because an inventor had a lucky thought, but apparently not the ability to devise a working model, he should be given such sweeping rights. It is analogous to giving the discoverer of a new country title to all the land that he found, simply because he first saw it. The simplest general remedy for such abuses in patent practice would appear to be to limit the life of all patents to a short period, say two or three years, provided the inventor does not reduce his invention to actual working shape, and then enter into its manufacture. Such a provision of patent law would also tend to discourage the buying up of patents by corporations to stifle competition.

* * *

THE ESSENTIAL AND UNESSENTIAL.

When an industrial plant grows, so that the final product is lost sight of in the production of each detail, it is a great temptation to forget the relation between one's own work and the final result arrived at. The essential feature in producing a machine is that it shall possess productive qualities when placed in the hands of the user. The drawings for the machine, for instance, are only a means to an end, and are essential only inasmuch as they aid the economical and accurate making of the machine. The outside finish and polish of the machine is not essential in itself, excepting as it aids in attracting customers who may not be able to judge so much of quality as of appearance.

The whole shop system of a plant is unessential in itself, and is of value only to the extent to which it aids the production. Yet—and here is the fatal danger in the growth of a large undertaking—when we get used to certain ways of doing work, and to certain shop systems, these seem essential in themselves, and the final end of the work is lost sight of. A draftsman finishes his drawings without judgment as to the actual purpose of his work. He lays down a great deal of work on fancy lettering and wonderful border lines, when these things are entirely unnecessary for the purpose of the drawing. A simple, correct, distinct drawing, giving the directions for the work in a clear-cut manner, is the best drawing, no matter if it looks plain to the artistic eye. The same is true of the shop and its methods. A certain foreman has a hobby that all parts shall be finished in a certain way, regardless of the final use of the part made. Many of the men get into the same habits; they complete their details of the machine often not with a view to the ultimate object of the work, but simply thinking of delivering a "nice job" to the next department. The tool-maker is, in common with the draftsman, often the worst offender. Jigs and fixtures are finished all over, an entirely wasted amount of work is laid down on dimensions not essential, and the work, while carefully done, does not show good judgment.

The success of an individual as well as of a firm depends largely on this judgment of essential and unessential features of work. Careful work does not mean unnecessary work. The greatest care should be taken with the necessary parts, and no time wasted which involves a useless expense. It is gratifying to see that our latest designs of machine tools show no machined surfaces excepting the working surfaces. Fifteen or twenty years ago many machines were practically finished all over, excepting the bed and legs, and this involved a double waste of labor as it increased the work of keeping the machines clean. The tendency of to-day is toward greater economy by means of *new methods*, but there is a great deal to be gained in the *elimination of the waste of the old methods* as well.

COMPRESSED AIR VS. ELECTRICAL TOOLS.

A great deal has been written in the engineering press regarding the relative superiority of compressed air and electricity for driving portable machine tools. Some writers have attempted to prove with figures and calculations that electricity is the cheaper, while others have presented arguments equally good on the face that compressed air is the better of the two motive powers. Very likely, however, an unbiased view of the subject would disclose the fact that either the one or the other of the motive powers may, at times, be the preferable one. For such purposes as riveting and calking, the use of compressed air is a foregone conclusion, but for almost all other small portable tools, electricity has gained on compressed air in popularity. It cannot be denied that in point of weight, the compressed air motor has advantages over the electric motor. The electrically-driven tools, are, as yet, considerably heavier, and their repair bills are higher than for their pneumatic competitors. The electric drive, however, is more efficient. Some experiments carried out by an English engineer indicate that 1¾-inch holes drilled in steel would take only 2 horse-power at the dynamo, while a compressed air drill on the same size of hole, at the same speed, takes 9 horse-power at the air compressor, so that the use of compressed air for motive power is rather more expensive, even if the repair bills for the electric tools are, say, twice as heavy as for pneumatic appliances. It seems then, in general, that the electric motor possesses advantages over its competitor, but in establishments where riveting and calking have to be done, compressed air is able to hold its own. There are in the market some fairly good electric riveting machines, but they do not possess the convenience and portability of the pneumatic hammer. In shops where an air compressor is required for some pneumatic tools for the purposes mentioned, it may be advantageous to use the air for other operations as well.

* * *

RAPID LOCOMOTIVE TIRE TURNING.

The development of powerful locomotive driving-wheel lathes during the past few years is well worth attention. The time when it required from one and one-half to two days to turn a pair of locomotive driver tires is not long ago, and to most of us it seems but yesterday when the turning of a pair of hard tires in four or five hours was considered a feat worth mention. The advent of high-speed steel revealed the general inadequacy of machine tools in power and rigidity, and the driving-wheel lathe was one of the first machines to be re-designed so as to work the new tool steels to the limit of capacity. What is the result? Within the past three years we have seen the notable exploit of turning ten completely finished pairs of locomotive tires in ten hours, or at the rate of one pair per hour. This feat has since been outdone, and now it appears commercially possible to turn a pair of badly-worn tires for, say, 56-inch wheel centers, in forty minutes, counting in the time required for putting in and removing the wheels from the lathe.

But there is quite obviously a chance for further reduction of time, if we are willing to provide still greater power and strength in the lathe. At the present time, the tire is broken down with a round-nose roughing tool which removes the worn tread and the top of the flange. Then follow three forming tools, the first removing the corners of the flange, the second forming the flange and the tread, and the third forming the outer coned part of the tread and rounding the edge.

These forming tool cuts require enormous driving power, but progress will require that the operations of turning a tire shall be reduced to two, these being the roughing cut made by round-nose tool, and the finishing operation, which will be done by a broad-faced tool of exact contour of the tire, forming the tread, edge and flange to the required shape all at the same time. The immediate objections raised will be the great power required of the lathe and the expense of keeping up the forming tools. The first objection will be valid so long only as it can be shown that the interest on the increased investment is not more than offset by the greater earning capacity, and the second objection already has been met by the proved durability of existing tire forming tools. When it can be shown that a forming tool will last for some weeks of constant use, its economy is proved.

With the two-operation wheel lathes fully developed, we may expect to see 60-inch tires turned in twenty minutes, counting the time required for putting in and removing the pair from the lathe. We fully expect to see twenty pairs of average locomotive tires turned in a day of ten hours. This will be increasing productive capacity with a vengeance. The first question that the individual thinks of is: "What good will it do labor?" That question is one that the twentieth century must answer.

* * *

ECONOMY OF NON-PRODUCTIVE LABOR.

It seems difficult for many persons in charge of industrial undertakings to comprehend that so-called productive labor, *i. e.*, labor directly or manually engaged in making the actual product sold, is not the only part of the organization actually profitable or productive. While, of course, it is recognized that the non-productive labor is a necessity, it is by a great many considered as a necessary evil, and any contemplated increase of a non-productive department is viewed with distrust and with the fear that its expense may mount so high as to devour the profits of the productive departments. An example of substantial economy effected by increasing the "non-productive" labor cost may be cited.

In a certain shop, where a great part of the work consisted in making certain tools to order, the customers ordering such tools often simply sent in samples, and requested that one or more tools be made exactly like the sample. The manufacture was of such a varied character that often many different machine operations were performed before the parts were finished, so that they had to pass through, say, six or seven different departments before completion. It was the custom, until lately, to send these samples directly into the shop, without making any drawing or sketch from them, and to let the men work directly to the samples, reproducing them as closely as possible. It is evident that, as the sample passed from department to department, the same dimensions were measured over and over again, perhaps half a dozen times. If the machinist working on the parts did not note down the dimensions at the time when measured, it might occur that each machinist working on a part had to measure the same dimension two or more times. The waste is evident; still, the time was charged as *productive* labor.

Later, somebody suggested that the proper thing would be to hire one more draftsman who would make sketches of all these samples, as they came in, and to have another man check the figures on the sketches from the samples before the sketch was sent in the shop. This necessitated that each tool be measured twice. The sample tool was then sent with the sketch into the shop, but the machinists were required to work to the sketch, the sample merely giving them an idea of the general appearance of the tool required. Now, the additional cost of another draftsman and the cost of checking by a more expensive man was, of course, charged as *unproductive* labor, and considered practically as a loss, but there is no doubt that a great saving was accomplished on each particular tool sketched up in this manner, inasmuch as the necessity of measuring the sample in every department, and in some departments several times, was avoided. At the same time, many mistakes that had previously occurred when one man had measured the sample and then worked to an incorrect figure, were also avoided by the checking before the sketch of the sample left the drafting-room. A permanent record of the tool made was also provided by this method.

The system referred to, is one of the very simplest kind, of course, but it is undoubtedly true that in hundreds of different cases the same principle can be applied in a great many shops to-day. Work is constantly done in a wasteful way by so-called productive labor, which, if properly systematized, could be done by so-called unproductive labor in less time, with greater accuracy, and with the possibility of saving considerable in the running shop charges. Let it not be forgotten then when men running machines do "unproductive" labor, their machines are idle, but the interest account on the cost of these machines runs along just the same.

ENGINEERING REVIEW.

CURRENT MECHANICAL EVENTS—LEADING ARTICLES OF THE TECHNICAL PRESS.

According to the *Mechanical World*, the Marconi Wireless Telegraphy Co., on February 3, commenced to accept messages from the public for transmission between London and Montreal. The charge is 15 cents a word, including land rates.

Notwithstanding the financial depression which prevailed during the last months of the past year, the trade and industry of the United States during 1907 exceeded all previous records. According to a table of summaries issued by the Bureau of Statistics, the production of anthracite and coke pig iron in 1907 exceeded 25,315,000 tons, while in 1906 the figure was 24,808,000 tons. Shipments of all kinds of products in nearly every case exceeded by from 5 to 12 per cent those of the previous year.

In the January issue of MACHINERY, engineering edition, we mentioned that the German government has taken considerable interest in the question of airships. How serious this interest really is is shown by the fact that, according to *Engineering*, the German Reichstag, after having granted the sum of $125,000 for the erection of a balloon shed, and for other incidental expenses, has made another supplementary allowance of $100,000 for the building of a second airship for experiments.

Not only is the large Krupp Works, in Essen, Germany, the largest industrial establishment anywhere in the world, but it also appears to be one of the best paying of all large industrial undertakings. It is reported that the dividend for the year 1906-7 was maintained at 10 per cent, the same as the year previous, the net profits for the year amounting to $6,250,000, after taxes, interest and all similar expenses had been paid. The capital of the concern was increased, during the year, from $40,000,000 to $45,000,000.

An interesting method, taken from a German source, for sharpening files when worn is given in *Industritidningen Norden*. The file is connected with the positive pole of a battery, consisting of 12 Bunsen elements, and is then placed in a bath consisting of 40 parts sulphuric acid, to 1,000 parts water. The negative electrode consists of a copper wire, coiled in a spiral around the file, but not touching it. The file is then exposed to the action of the current for about ten minutes. It is stated that files treated in this manner can be sharpened so that they are nearly as good as new.

An International Industrial Exhibition is to be held at Toulouse, France, beginning May 1, and continuing until September 20, 1908. American firms are invited to exhibit, and the directory of the exhibition has offered to undertake to receive their exhibits, and to send them back at the end of the exhibition. Applications for admittance are to be made either to the American Consul, or to the Directory of the Exhibition (Commissariat-General, Exposition Industrielle, Toulouse, France). The goods will be transported back to the French sea-port, free of charge, by the French railway companies.

A practical test of reinforced concrete to determine whether it is safe to remove the forms and supports, was, according to *Engineering News*, given by Mr. C. A. P. Turner, in the course of an address to the Northwestern Cement Products' Association, at Chicago, Ill. The speaker said that it was difficult to formulate a comprehensive rule, covering the variable conditions entering into the problem of the setting of concrete, but it is easy to demand that concrete not frozen shall be set sufficiently hard, so that, if tested by driving a 20-penny wire spike into it, with an ordinary carpenter's hammer, the spike shall double up after penetrating approximately one inch, and if the concrete is not sufficiently good to withstand this test, after having had ample time to set, it is not good enough to remain and do business in a structure that may be deemed safe.

The *Engineering Record* mentions some interesting tests which have been made by Mr. A. E. Outerbridge some time ago for establishing the amount of swelling of cast iron by subsequent heating and cooling. These tests proved that it is possible to increase the volume of cast-iron bars as much as 40 per cent. A bar measuring one inch square by 14 13/16 inches long was heated in a gas furnace to 1,450 degrees F., and then cooled 27 times, after which careful measurements showed that the bar had increased in length to 16½ inches, and to a cross section 1⅛ inch square. Further heatings, however, increased the size of the bar only slightly. As this action is identical with the action of cast iron in super-heating steam fittings, it is quite generally thought that the difficulties experienced with such fittings are direct results of the many variations of temperature rather than the high temperatures themselves.

It has been stated by several authorities that high-speed steel milling cutters are not very successful in cutting hard materials. Messrs. Armstrong's Arms factory, England, however, constantly employ high-speed steel milling cutters for cutting nickel-chrome steel armor-plate, using a cutting speed of 75 feet per minute. Experience with high-speed steel cutters, used for cutting the teeth of gears for motor cars, which are made of a very hard material, putting a severe strain on the cutters, has shown that, under such circumstances, high-speed steel milling cutters will last three and one-half days, without grinding, as compared with one day when ordinary carbon steel milling cutters are used, and at the same time, the feed per revolution could be increased 1/3, so that the high-speed steel cutter, in addition to cutting at a higher speed, and lasting a greater length of time, without being ground or recut, would stand a greater strain as well.

An Italian correspondent to the *Times Engineering Supplement* states that at a meeting of naval and mechanical engineers, held in Genoa early this year Signor L. d'Adda, an Italian naval engineer, presented a proposition for the protection of armored war vessels with reinforced concrete instead of steel plates. This system, he stated, has been used with excellent results for land fortifications. While following the operations of the Russo-Japanese war in the Far East, he had been impressed by the resistance offered by reinforced concrete against heavy projectiles. The weight of plates made of this material would be about the same as of plates made from steel, and the space required was not more than of a metal armor, while the cost would be very considerably less. It is stated that the Ministry of Marine of Italy has directed that some of this concrete protection shall be thoroughly tested at one of the naval stations.

In a paper, read some time ago, before an English engineering society on the subject of illumination, the speaker called attention to the false economy of requiring people to work by poor light. In comparison with the cost of labor, the cost of light is but trifling. He took the illustration of a man receiving from $2.00 to $2.50 a day, or about 25 cents an hour, and compared this labor cost with the cost of a 16 candle-power lamp, burning 10 hours, which he estimated to be only about 1⅕ cent. Yet there are thousands of skilled mechanics, who are handicapped in their work by insufficient and ill-directed light. In the case of bad light in a factory or shop, the personal inconvenience caused thereby means a reduction both in the quality and quantity of the output, thus producing a loss, in comparison with which the cost of illumination is trifling. One must bear in mind that most men, engaged in mechanical work, are guided almost exclusively by the sense of sight, and the importance of furnishing good illumination ought to be apparent, although it cannot be denied that this question, in many cases, is sadly overlooked. To furnish up-to-date machinery and tools, to pay good wages for skilled labor, and then to handicap the men by insufficient, or improperly placed, light, ought to be so apparent a fallacy that it would hardly be necessary to call attention to it.

The following interesting information regarding the influence of variable load on iron beams, is taken from *Industritidningen Norden*. It is usually assumed that variable load, that is, continued loading and unloading of iron beams, diminishes their strength, but it is claimed that at the laboratory for the testing of materials in Grosslichterfelde, near Berlin, it has been found that this assumption is not based on actual facts. On application of a department of the Government Railroads, 24 beams taken from an old railway viaduct, which had been built in 1856, were tested. Investigations were made to establish the relationship between the original and the present strength of the iron, by comparing the beams from the heaviest loaded and the less heavy loaded portions of the bridge, and also by comparing the strength of two identical parts of the same beam, of which one had been annealed, while the other had been left in its original condition. As is well known, the reduced strength and elasticity of iron, caused by too heavy stresses, can be regained by annealing. If then, by the variable load, the strength of the iron had been reduced, the annealed beams would have shown a greater strength, when tested, than those which had not been annealed. The testing of the strength of the materials, however, showed that the strength of the iron had not been decreased by the variable load, which, for 51 years, had been applied to the bridge. On the other hand, in nearly all cases, it was proved that the parts which had been most heavily loaded showed greater strength than those which had been exposed to less heavy loads.

STORING COAL UNDER WATER.

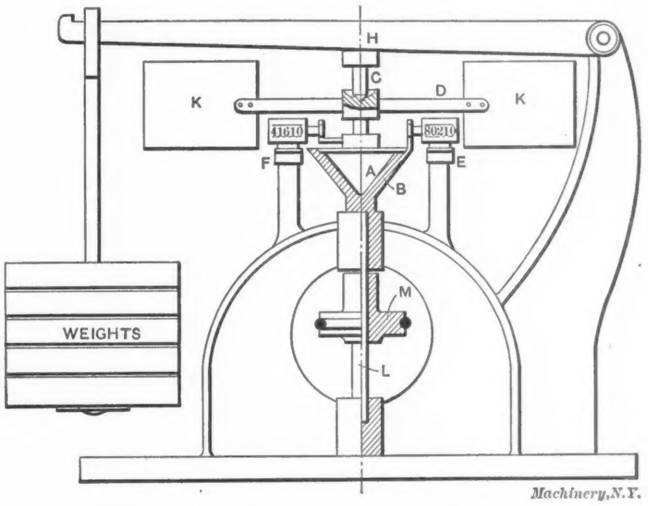
In our July and December, 1906, issues, we referred to the practice of the Western Electric Company of storing coal under water. This is admittedly the best way known for minimizing deterioration, as well as of avoiding spontaneous combustion or accidental ignition. The advantages of this method of storage, says the *Railroad Gazette*, have been determined by experiments in Great Britain within the past five years. The British Admiralty has been the most noted as well as the most extensive investigator, although the studies were antedated by individual experimenters, who were able to record definite and conclusive results. That the idea has been in use in this country since about the time attention was first drawn to it in England, may, however, be new to many, for already in 1902 the Western Electric Company, having had much trouble from spontaneous combustion with Illinois coal stored in quantity, determined on water storage as the simplest and most effective preventive. A large hole was dug in the ground, the coal dumped in, and flooded. When the large new plant at Hawthorne was built about two years ago, the scheme was elaborated to its present proportions. A concrete pit to hold 10,000 tons was built, with tracks across on concrete arches, and the reserve supply of coal is kept in the bins thus formed. To deposit the coal in these submerged bins costs about 5 cents a ton. It is removed by a locomotive crane with a grab bucket. The water for the bins comes from the roofs of nearby buildings. The cost of the pit, which is 310 feet by 114 feet by 15 feet deep, was at the rate of $7,000 per 1,000 tons of capacity. When the coal is used, it is loaded into cars, allowed to stand 24 hours to drain, and then put into the overhead bunkers of the power station, from which it feeds to the stokers. It is therefore used within 48 hours after coming from the pit, and burns well. Since the water removes all of the finely pulverized material, it is equivalent to using washed coal. The British experiments included storage in both sea and fresh water, and in the former instance the quality of the coal actually was improved, presumably from its permeation by the salt. The effect of salting the water has not been tried at the Western Electric Company's pit.

APPARATUS FOR TESTING THE LUBRICATING QUALITIES OF OIL.

Engineering, February, 1908.

An interesting little apparatus intended for testing the lubricating qualities of oils, made by Messrs. John Blake, Ltd., Accrington, England, is shown in the cut below. The apparatus, in general, consists of a vertical shaft *L*, driven by a belt on pulley *M*. At the upper end of the shaft *L* is mounted a conical cup *B*. Into this cup is accurately fitted a metal cone *A*, on which, in turn, is mounted a vertical spindle *C*, carrying two horizontal arms *D*, provided with two vanes *K*. When the spindle *C* is revolving, the air resistance on the vanes *K* will tend to retard the movement. A revolution counter or speedometer *E* is connected to the revolving cup *B*, and one speedometer *F* to the revolving cone *A* inside of the cup. The action of this device is as follows:

A small quantity of the oil or lubricant to be tested is placed in the cup *B*, and the loose cone *A* with its vertical spindle and vanes is placed in the cup. The cone has a groove in its side, in which a small quantity of oil may remain, so as to prevent all the oil being pressed out of the cup *B*, when the cone *A* is placed in position. The lower spindle, with the



Apparatus for Testing the Lubricating Qualities of Oil.

cup attached, is then revolved by means of its belt and pulley, at a speed of about three hundred revolutions per minute, and as the cup revolves with the cone inside it, the friction between the cup and the cone causes the latter to revolve also, but at a lower speed than the cup, on account of the resistance offered by the vanes, when passing through the atmosphere. After the machine has been running for a given time, say a couple of hours, the number of revolutions made by the cup and those made by the cone are noted. Then a second oil or lubricant may be put in, after first removing completely all traces of the one previously tested, and a note made of the number of revolutions made respectively by the cup and cone during the same period of time as in the first

TESTS OF LUBRICANTS.

Sample Number.	Quality of Oil.	Duration of Test.	Revolutions of Cup.	Revolutions of Cone.	Percentage of Cone Revolutions to Cup Revolutions.
1	Sperm	2 hours	36,540	12,300	33.6
2	Mineral	2 hours	36,800	14,800	40.2
3	Mineral	2 hours	36,300	16,100	44.4
4	Mineral	2 hours	36,350	17,400	47.8
5	Mineral	2 hours	36,580	18,600	50.8
6	Mineral	2 hours	36,280	22,100	60.9

test. If the number of revolutions made by the cone be less with the second oil or lubricant than with the first, it naturally follows that the friction between the cup and the cone has been less, and therefore that the second oil or lubricant is better. Many oils can be compared in this way, and their lubricating value can be put down in the exact order of merit. The accompanying table gives the results of a few tests which have been made on a number of different kinds of oils with this device.

When heavy oils are tested, the lever *H*, having weights hung on its end, as shown in the cut, is used for producing the required pressure between the cone and the cup.

THE STUB-TOOTH GEAR.

Abstract of pamphlet entitled "The Stub-Tooth Gear," published by the Fellows Gear Shaper Co., Springfield, Vt.

This little pamphlet deals with the advantages of the "stub-tooth" gear, a form of shortened and strengthened involute tooth cut with stub-tooth cutters. The pamphlet states the case for short teeth of greater obliquity than 14½ degrees standard so conveniently that it seems worth while to make the following condensed abstract of it, largely in the words of the original:

With the constantly increasing use of gears for transmitting power in widely varying quantities, the question of the correct shape and size of gear teeth becomes of far greater importance than ever before. It is not sufficient that a gear be well cut and the teeth properly spaced, but the shape and proportions of the tooth itself must be carefully considered.

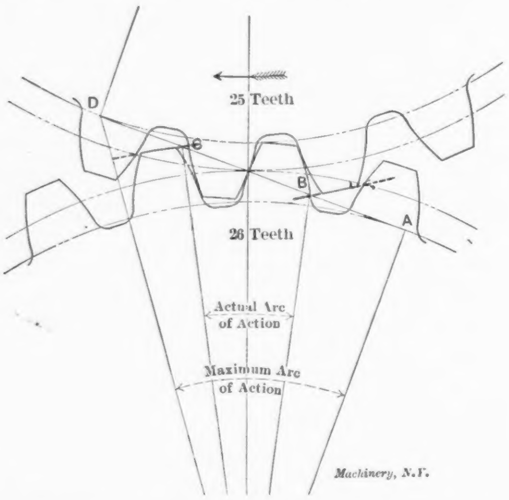


Fig. 1. Comparison of Actual with Maximum Arc of Action in the 14 1-2 Degree System.

The two most important features are the securing of the nearest approach to a rolling action that it is possible to obtain and the strongest tooth that will meet this condition. The first includes easy running, reduces the friction to the lowest point, and consequently has the least wear in action.

In the matter of length, it is a fallacy to argue that teeth should be made as long as possible in order to have two or more teeth in contact at once. An equal division of the load is never possible between two contact points, and it can be shown that the lengthening of the tooth to produce more points of contact gives an excessive sliding action at certain portions of the tooth action, especially with gears 14½ degrees of standard angle. By increasing this angle, the teeth may be shortened so that only such portions of the curve are used as will give nearly a complete rolling action. This increase in obliquity has been advocated before, but its advantages are very limited, if a tooth of the standard length is retained.

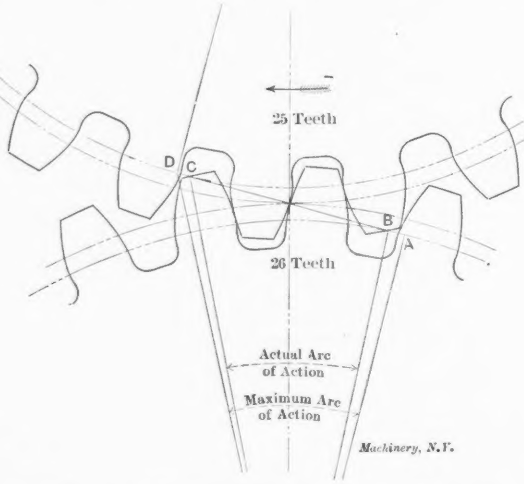


Fig. 2. Comparison of Actual with Maximum Arc of Action in the Stub-tooth System.

In Figs. 1 and 2 are shown comparisons of the tooth form of a gear of the standard and of the stub-tooth, the driver having 25 and the driven 26 teeth. If, in the diagrams, the gears are supposed to rotate in the direction of the arrow, the theoretical action begins at *A* and ends at *D*, the line *A D* being termed the "line of action." It is obvious, however, that the actual action can only begin at *B*, where the outside diameter of the upper gear intersects the line *A D*, and ends at the corresponding point *C*. Drawing the radial lines from these points to the center *O* (not shown) the triangle *A O D* defines the maximum or the greatest possible arc of action, and *B O C* the actual arc of action.

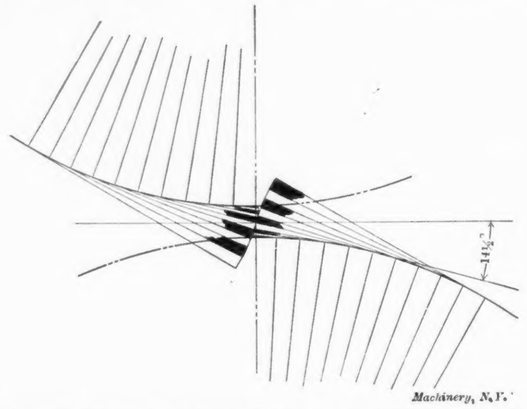


Fig. 3. The Involutes are those of Fig. 1. The Alternate Shaded Divisions show the Portions of Each which are in Contact with the Corresponding Portions of its Mate during Equal Angular Movements.

In Fig. 3 is shown an involute curve of 14½ degrees obliquity of each of the gears, the curves being of sufficient length to cover the maximum arc of action, and drawn to the same scale as Figs. 1 and 2. The alternately shaded divisions of the curves show the portion of each that is in contact with its mate during an equal angular movement of the gears. In Fig. 4 is seen a similar diagram for a tooth having an angle of obliquity of 20 degrees.

In Figs. 5 and 6 the involute curves of Figs. 3 and 4 are developed into straight lines, marked off into divisions corresponding with the divisions on the involutes. These division points are connected by cross lines. It will at once be seen that the angularity of these cross lines may be taken as a measure of sliding that takes place at any given point, since a large division on one involute making contact with a small division on the other involves an amount of rubbing measured by the difference between the two distances. To any one who has labored under the impression that if the involute curves of a pair of gears are correct, the action is nearly a rolling one, a comparison of these diagrams will be both interesting and instructive. Two points will be noted.

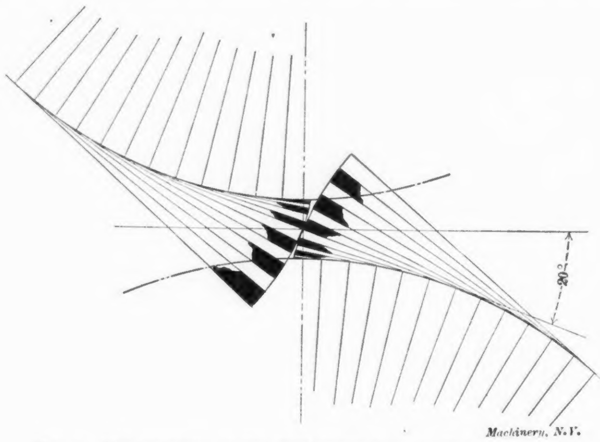


Fig. 4. The Involute of the Stub-tooth Gear in Fig. 2, treated as in the Preceding Figure.

First, on account of the greater angle of the line of action of the stub-tooth, the maximum arc of action is much increased.

Second, the ratio of the *actual* to the *maximum* arc of action of the stub-tooth is much less than in the standard.

This latter point is a very important one, as we thus eliminate contact at both ends of the line of action. When we

realize that this is the portion of the action in which the greater part of the sliding takes place, with its inevitable wear, we see that it is a good thing to cut it out if possible. The point of the tooth which wears out the flank of its mate is removed with the adoption of the stub-tooth, and this reduces the friction while increasing the efficiency. A comparison of Figs. 5 and 6 shows that the action of the stub-tooth is as nearly a rolling one as it is possible to obtain. The action of the standard tooth at the base line is that of a stone-boat being dragged over the ground, while the action of the stub-tooth can be compared with the same stone-boat mounted on wheels.

It is, of course, impossible to entirely eliminate the wear between the teeth of gears working under a load. But if the wear can be evenly distributed over the entire working face of the tooth, the correct form of tooth is retained indefinitely, and a worn-out gear should, aside from the excessive back-

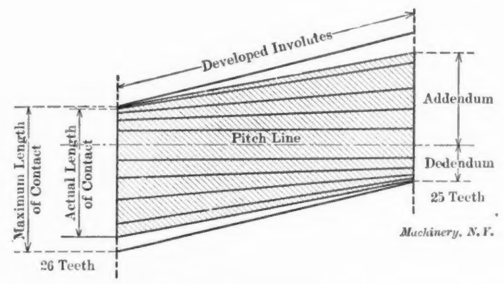


Fig. 5. The Involutes of Fig. 3 Separated and Developed into Straight Lines with the Division Points Connected as shown. The Angularity of the Connecting Lines is a Measure of the Rubbing.

lash, run as well as a new gear. And, if this wear can be evenly distributed, the durability of any gear will be increased many times.

We have so far discussed only the points of efficiency and durability, but there is another advantage of the stub-tooth over the standard form, and one which some might think entitled to first consideration, especially in the transmission of any considerable amounts of power; this is the advantage of greatly increased strength.

A comparison of the two diagrams in Fig. 7 (drawn according to the well-known method proposed by Mr. Wilfred Lewis) shows an increase in strength for the stub-tooth form of 80 per cent. It will be noted by comparing different combina-

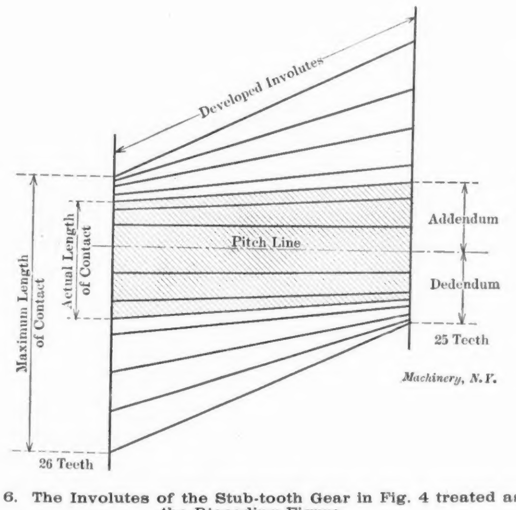


Fig. 6. The Involutes of the Stub-tooth Gear in Fig. 4 treated as in the Preceding Figure.

tions of gears that the increase in strength is greatest for pinions, which are almost invariably weaker than the gears they run with.

To understand the importance of this consideration of strength, it may be mentioned that if comparisons are made between a 15-tooth 6-pitch 14½-degree gear and one with 20 teeth 8/10 pitch of the stub-tooth standard, both having the same diameter, it can be shown that the stub-tooth, though shorter and of finer pitch, has 20 per cent greater strength, and while the bearing surface per tooth is shorter, the total area of bearing surface is 6 per cent greater.

Some of those who are not entirely familiar with this system of gear teeth have made the mistake of thinking that it consists simply of the shorter tooth than the standard form, while retaining the same pressure angle, and have therefore opposed it on the ground that the arc of action, in the case of a small pinion, is not equal to the pitch arc, and that the action is therefore not continuous, because one tooth is out of action before the next tooth takes up the load.

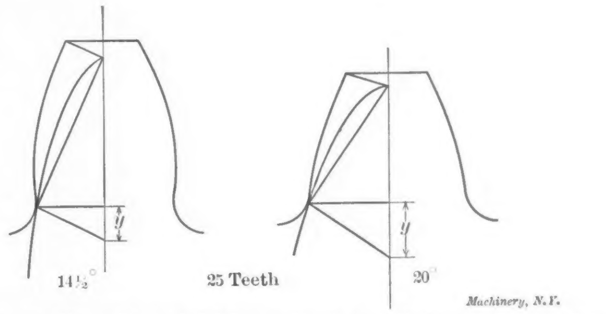


Fig. 7. The Strength of a 14 1-2 Degree Tooth and a Stub Tooth Compared by the Wilfred Lewis Method; the Strength is measured by Dimension *y*.

It should be thoroughly understood, and we wish to emphasize the fact as much as possible, that the increased angle of obliquity is an essential and vital part of the stub-tooth system, and that with this increased angle, the arc of action is as long as that of the 14½-degree tooth.

Fully one-third of the cutters made by the Fellows Gear Shaper Co. are now of the stub-tooth form.

[We have described the method of sizing the stub-tooth gear in a previous issue of MACHINERY. See "How and Why" in the July, 1907, issue. This method of sizing the teeth is very convenient for use with the Fellows gear shaper, in which the depth of cut is obtained by referring to graduations numbered to correspond with the diametral pitch used. We cannot escape the belief, however, that it is a serious error to inaugurate a system in which the addendum of the tooth bears no definite relation to the pitch. While the convenience of the operator is worth consideration; we believe it could have been obtained in other ways that would not have involved the irregular determination of the addendum, as now practiced.

The argument for shortened addendum and increased pressure angle, given in this pamphlet, seems to us worthy of the serious attention of mechanics. The conclusions are, we believe, inescapable, and perhaps even more might be said from the standpoints of efficiency and durability in behalf of a change from the old standard form.—EDITOR.]

FRICTION AND LUBRICATION.

Abstract of paper read by Dr. J. T. Nicolson before the Manchester, England, Association of Engineers, November 23, 1907.

The present paper does not give much attention to dry friction, or to the laws of resistance when one solid moves over another. Its chief aim is to attempt to give some definite ideas about the resistance offered to the relative motion of lubricated surfaces, and, in particular, relates to journals and bearings as used in engineering practice. Experimental results obtained by Stribeck, Dettmar, Heimann, Lasche, and others, have been utilized for framing rules which indicate that some views commonly held in regard to bearings are not correct. In particular, the idea that the length of the bearing should increase in proportion to the speed, is shown to be erroneous.

Dry Friction.

When one solid rubs upon another without any lubricant, the resistance offered to relative motion is due either to actual abrasion or to molecular interference between the two surfaces. Even though a metallic surface may appear to be perfectly smooth to the eye, its real condition, if viewed with a powerful microscope, resembles that of a rugged mountain system. When one surface is slid upon another, these surfaces exercise a resisting force. The following laws may be considered as generally covering the question of dry friction:

1. Within certain limits, the frictional resistance may be said to be proportional to the load, and to be independent of

the extent of the surface over which the load is distributed; but when the pressure or load per unit area is large, the friction increases at a greater rate than the load, or, in other words, the coefficient of friction increases with the pressure.

2. The coefficient of friction varies with the speed of motion. It is greatest when the motion is slowest, and when one body is just commencing to move relative to another, we have what is called friction of repose. This friction has been found by experiments to be from 0.3 to 0.4 for iron upon iron; for moderate speeds, the friction varies from 0.15 to 0.25 for the same material; and for speeds from 10 to 90 feet per second, the coefficients of from 0.10 to 0.20 have been found by experiments.

3. The friction of solids with no lubricant interposed has been found to diminish as the temperature increases. This is due to the fact that abrasion is easier at high temperatures.

Friction with Lubrication.

When some lubricant is placed between moving bodies, the valleys or the uneven surfaces are leveled up, and the intensity of the molecular action is diminished. For the frictional work when a shaft rotates in a well-lubricated bearing, we may state the following formula, expressing the frictional work done per revolution:

$$\text{Frictional work per revolution} = \frac{\pi d u W}{12} \text{ foot-pounds.}$$

In this formula,

d = diameter of shaft, in inches,

u = coefficient of friction (0.15 on an average),

W = load on the bearing in pounds.

This formula holds true when there is plenty of oil, so long as the speed is small. If we take as an example the case of the spindle for a 10-inch lathe, running slowly, with a weight of 3,000 pounds carried by the front bearing, which is 3½ inches in diameter, then the friction work per revolution is

$$\frac{\pi \times 3.5 \times 0.15 \times 3{,}000}{12} = 412 \text{ foot-pounds per revolution.}$$

If a cut were ¼ inch × 1/16 inch on soft steel, the cutting force would be, say, 3,500 pounds, and on a 20-inch face-plate diameter the work spent in cutting per revolution would be

$$3{,}500 \times \frac{20\pi}{12} = 18{,}300 \text{ foot-pounds.}$$

The work lost in friction by the journal is therefore 2.26 per cent of the useful work. A similar calculation for a 48-inch lathe would show a loss of about 10 per cent. These great frictional losses constantly occur with lathe spindles or other rotating shafts, revolving slowly, even when abundantly fed with oil, and indicate the necessity for using measures to preserve a separating film of oil between the shaft and bearing, and not to allow them to run in metallic contact. This is more difficult to accomplish at slow than at high speeds.

Automatic Lubrication.

The following rules for supplying bearings with oil will give the best results in practice: If the oil is fed in by the ordinary cup and syphon, or by a ring or centrifugal method of supply, it should be made to flow onto the journal at the place where the pressure is least. The oil should therefore be fed from a point situated in the top rear quadrant of the bearing when the journal is loaded by gravity only, and the point should be further back the slower the speed. This applies, then, especially to the large lathes. If the loading of the journal is principally due to cutting force acting upward upon it, the feed should be placed in the bottom front quadrant, and nearer the front, the slower the speed of rotation. This meets the case of the smaller-sized lathes.

The compromise ordinarily effected to enable the lubricant to enter, whatever may be the direction of the loading, is the simple one of fitting the oil cup on the top of the bearing. This seems almost the only thing to do in the case of automatic lubrication, but it is the correct position only when the resultant force upon the journal, due to gravity and cutting force, etc., acts nearly horizontally and from front to rear.

Forced Lubrication.

When the lubricant is supplied by mechanical means at a fixed rate and at any required pressure, it must be fed in at the points of greatest oil pressure in the bearing. For large lathes, where gravity is more important, the region of greatest pressure lies in the rear bottom quadrant. For small lathes, on the other hand, in which the force on the spindle acts upward, owing to the cutting force being relatively greater, the maximum oil pressures occur in the front top quadrant. To meet all contingencies, it would appear on the whole best, in the case of forced lubrication, either to force the oil in at the back of the bearing, well below the center, or preferably to fit three alternative branches from the oil pressure supply pipe to the back, top, and front, any one of which may be turned on at will to suit the conditions of working.

Frictional Resistance Due to Viscosity.

In describing the phenomena occurring when a journal rotates in a bearing, we have, so far, not alluded to the nature or magnitude of the frictional resistance experienced when there is an abundant supply of lubricant completely separating the former from the latter, and preventing any metal-to-metal contact. It is frequently stated that "there is no friction without abrasion," or, in other words, that unless two metals rub against each other, there can be no resistance due to relative motion. This, however, is not the case. When a film of lubricant is interposed between two metallic surfaces, there is a resistance to relative motion of these surfaces due to the shearing or transverse distortion of the oil film.

This resistance does not depend on the load. It is governed only by the area of viscous fluid to be sheared, and the viscosity of the oil, *i. e.*, the kind of oil and its temperature (with which the viscosity greatly alters), and it also gets greater the smaller the thickness of the film, so that if the shaft is a close fit within its bearing, the resistance to motion will be greater than if the fit is an easy one.

There are very few cases in engineering practice where a journal rotates with a uniform thickness of oil around it, and it is only at very high speeds that this takes place. At moderate and low speeds, the shaft moves to one side an amount depending on the speed of the load, the eccentricity for any given load becoming less, the greater the speed. We have already said that the frictional resistance depends on the thickness of the oil film. Experiments have shown, however, that the thickening of the film on one side of the shaft is more than counteracted by the thinning of the film on the other, so that, in general, the friction gets greater when the journal becomes more eccentric.

Considering, therefore, the bearing running slowly, in which a lubricant has just formed a complete film all around the shaft, it will have its maximum amount of eccentricity, and the frictional resistance will, on this account, be large. As the speed increases, the eccentricity diminishes. The friction increases with the speed, but it diminishes, on the other hand, with the eccentricity. Experiments show that at first there is a diminishing and then an increase, so that the coefficient of friction attains a minimum value which depends on the circumstances in each case. With further increase in speed, the diminishing of friction, due to the lessening eccentricity, becomes insignificant, and after a certain interval, the simple law of friction is followed, whereby friction increases in proportion to the velocity of rubbing.

For speeds greater than at from 20 to 80 feet per minute, the temperature of the oil film also exerts its influence. This temperature rises above that of the bearing, and its viscosity becomes reduced. The frictional resistance then increases less rapidly than in exact proportion to the speed. The faster the journal runs, the more the temperature of the oil film rises above that of the bearing, and the thinner or less viscous becomes the oil. Thus, for speeds from 50 to 90 up to about 450 feet per minute, the coefficient of friction is proportional to the square root of the speed of rubbing. For speeds between 450 feet and 800 feet per minute, the friction increases more slowly, and varies as the fifth root of the velocity. For speeds as high as 3,600 feet per minute and upward, the influence of the speed disappears altogether, and the conclusion is arrived at that for bearings of high speed generators, for

instance, driven by steam turbines, whose rubbing speeds are nearly a mile a minute, the coefficient of friction is the same, whatever be the speed.

Application of Results of Experiments to the Design of Bearings.

In endeavoring to apply the theoretical explanations and the experimentally found formulas, the question arises: What is the proper proportion of length to diameter, under any given condition, as to load, speed and kind of lubrication? According to hitherto accepted rules, the length of the bearing should increase with the load and with the number of revolutions. The experiments and formulas arrived at by the author, indicate, however, that the heat developed in the bearing depends only upon the rubbing velocity, and is quite independent of the length of the journal. We cannot, therefore, hope to lower the temperature by lengthening the bearing. The heat generated increases as fast as the area for dissipating it increases, and, although by lengthening the journal, the bearing pressure is diminished, the frictional resistance and the heat generated are increased. On the other hand, we know from experience that journals must be made long for high speeds, and the above calculations seem, at first sight, to be in conflict with accepted practice. The explanation of this is as follows: While it is true that the final temperature to which the bearing will rise after a long run, under a given load, and with a given lubricant, depends only on the diameter of the spindle and the speed of revolution, that is, only upon the rubbing velocity, and not at all upon the length of the journal, we have to remember that if the finally attained temperature be too high, the lubricant will be squeezed out unless the bearing pressure is low.

Another conclusion arrived at by these experiments, contrary to the view usually accepted, is that the length of the bearing must be greater, the slower the speed. This, however, is clearly correct, for the slower the speed, the greater difficulty has the shaft in dragging in its supply of oil to meet the required demand, in opposition to the bearing pressure which is squeezing it out, and consequently the unit bearing pressure should accordingly be lower in order to enable the journal to maintain its oil film unbroken.

Journals for Heavy Loads at Slow Speed.

One kind of bearing which presents special conditions, and which is frequently met with and has to be dealt with in practice, is that in which a journal has to run under a heavy load at a very slow speed. What we have here to guard against is the entire collapse or tearing asunder of the film of lubricant, owing to the slow speed at which the bearing is being worked; and when once the tearing of the oil film begins, the journal is unable to bring up a fresh supply, owing to its small surface speed.

Calculations and experiments show that it is impossible to give the large dimensions to the front bearing of a heavy lathe that would be necessary to prevent the oil film from being broken at such slow speeds; and, as a matter of fact, lathe spindles turning at the slow speeds used for heavy cuts inevitably run metal-to-metal with their bearings, giving rise to the high frictional resistance corresponding to the coefficient of friction of 0.15 for greasy metals. The work thus spent and wasted on friction and wear may amount to from 2 per cent to 10 per cent of the total useful work expended on cutting. From ¼ to 9 (according to size) horse-power is, therefore, wasted on the friction of the front journal alone when the lathe is running at these slow rates with a heavy job between centers. Even if the working pressure is light, and the thrust on the front journal is due to the standard cut only, it can be shown that 2½ per cent of the useful work is spent on friction on any size of lathe when the speeds are so low as to squeeze out the oil film.

We are here face to face with a very serious loss of power, and a correspondingly large amount of wear of the spindle and in the front bearing, not at all due to high speeds of rotation of the spindle; and it is owing to this that the elaborate arrangements for adjustment of the spindle in a lathe headstock have to be provided.

It is impossible to give enough area in the front bearing of a lathe head-stock to prevent metallic contact of journal and brass at the slower speeds, if dependence is placed upon the lubricant being carried in by the ordinary action of the shaft's rotation, the supply being automatic. By using a force pump, however, and injecting a stream of moderately heavy oil into the bearing at the place where the pressure is greatest, it is possible to raise the journal off the brass even when at rest, and to keep it floating with a film of oil interposed between itself and the bearing when in motion, be that motion as slow and the load as high as it may. If metal-to-metal contact can in this way be prevented at slow, and by the ordinary methods at high speeds, there seems to be a possibility that wear may be entirely eliminated. If this be so, it follows that adjustments for wear are unnecessary, and instead of the elaborate and expensive designs of front and back bearings which are now used, we may expect that a simple solid bush of ample thickness will meet every requirement. Such a solid bush, of hard bronze round the steel spindle, has a great deal to recommend it from the point of view of accuracy of fit, solidity, and stiffness, as compared with the intricate methods of adjustments now common.

Modern Practice for Lubricating Bearings.

The chief distinction between the modern and the older methods of lubricating bearings lies in that the oil is no longer supplied drop by drop, as formerly, but in an abundant stream, the oil serving the purpose not only of lubrication, but of carrying away the heat.

For high speed bearings, the principle most often adopted is that of the "closed circuit," that is, the oil is used over and over again; after dropping off the journal into a collecting reservoir, it is filtered and used anew, being automatically supplied to the journal at any suitable point. A cooling arrangement is sometimes fitted in the reservoir so as to remove the heat from the oil, and consequently also from the bearings. The system of forced lubrication is also adopted to a great extent. The oil is then, by means of a pump or other suitable device, pressed in between the rubbing surfaces so that the journal floats on the heavy film of lubricant.

Lubricating Horizontal Bearings.

The most common method of lubrication for horizontal journals running at high speed is the ring-oiled bearing, in which a loose ring, resting on the shaft, turns with it, dipping into the oil reservoir at the lower side, and bringing up the oil to the top surfaces of the journal, from where it flows over into the oil grooves. No ribs or other projections should be fitted on the rings, as such arrangements produce a resistance to their passage through the oil bath, and bring them to a stand-still. At high speeds, the centrifugal force renders the flow of oil from the ring to the journal difficult, and scrapers are used for diverting the oil into the oil channels. These, however, should never touch the ring, as they will then stop its motion.

Self-oiling bearings having rings fast on the shaft are not much used. The fast ring cannot stick, but it requires a longer design of bearing. The ring may act as a collar where end-wise motion is to be prevented; but as such motion is usually an advantage, the ring should ordinarily be attached to the shaft so that it can slide on its key. For high speeds, the scraper may be used with fast rings, to overcome the centrifugal force.

Forced Lubrication.

By the use of a pump to force the oil drawn from the reservoir into the bearing, to the point of maximum pressure, the length of the bearing can be very much diminished even for the slowest speeds, especially for journals whose load and rotation direction do not change. For such bearings, the length need, in all probability, not be more than equal to the diameter of the shaft. With such bearings there ought hardly to be any wear at all. The system is extensively used in high speed steam engines and gas engines.

* * *

The best way to get along with a competitor is to treat him well. If you abuse him unjustly, you get the name of being envious, and do yourself harm. Pry into your own business instead of his, and you will be better respected and more prosperous.—*Cincinnati Enquirer.*

DERIVATION OF FORMULA FOR DETERMINING SPUR GEAR CUTTERS FOR CUTTING SPIRAL GEARS.*

H. W. HENES.†

The formula $N_c = \dfrac{N}{\cos^3 a}$ is generally accepted as the correct one for determining the proper spur gear cutter to be used in cutting a desired spiral gear. In this article is given the derivation of the formula. The following notation is used:

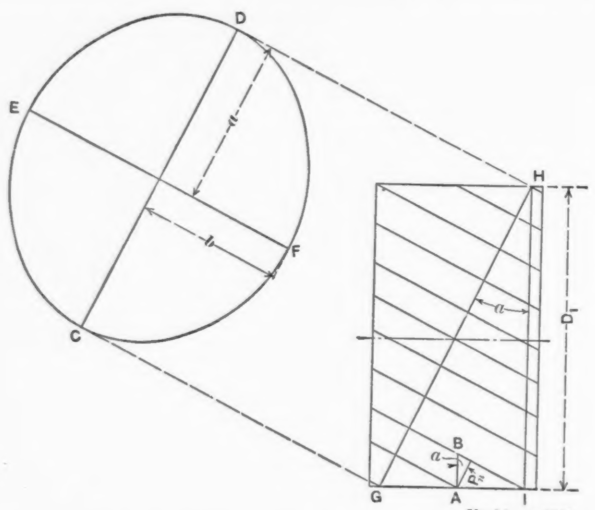
N_c = number of teeth in spur gear for which cutter is intended.

N = number of teeth in the desired spiral gear.

a = the angle which the direction of the spiral makes with the axis of the gear.

Let P_n be the perpendicular distance between two consecutive teeth on the spiral gear, and let D_1 be the diameter of the spiral gear. Let the gear be represented as in the cut, and pass a plane through it perpendicular to the direction of the teeth. The section will be an ellipse as shown in *CEDF*. Designate the semi-major and semi-minor axes by a and b respectively.

Now, N_c is the number of teeth which a spur gear would have if its radius were equal to the radius of curvature of the ellipse at E. Therefore, it is required to determine the radius of this curvature of the ellipse. This is done as follows:



Machinery,N.Y.

Diagram for Deriving the Formula for Determining Spur Gear Cutter for Cutting Spiral Gears.

From the figure we have:

$$2b = \text{axis } EF = D_1 \qquad (1)$$

$$2a = \text{axis } CD = GH = \frac{HI}{\cos a} = \frac{D_1}{\cos a} \qquad (2)$$

From (1) and (2) we have for a and b,

$$b = \frac{D_1}{2} \qquad (3)$$

and

$$a = \frac{D_1}{2\cos a} \qquad (4)$$

It is known, and shown by the methods of calculus, that the minimum curvature of an ellipse, that is the curvature at E or F, equals $\dfrac{b}{a^2}$. Taking the values of a and b found in (3) and (4), we have as the curvature at E:

$$\text{Curvature} = \frac{b}{a^2} = \frac{\dfrac{D_1}{2}}{\dfrac{D_1^2}{4\cos^2 a}} = \frac{4\,D_1\cos^2 a}{2\,D_1^2} = \frac{2\cos^2 a}{D_1} \qquad (5)$$

It is also shown in calculus that the *curvature* is equal to $\dfrac{1}{R}$, where R is the *radius of curvature* at the point E. Therefore from (5) we have:

$$\frac{1}{R} = \frac{2\cos^2 a}{D_1}, \text{ whence } R = \frac{D_1}{2\cos^2 a} \qquad (6)$$

[Formula (6) could have been arrived at directly, without reference to the minimum curvature of the ellipse, by introducing the formula for the radius of curvature in the first place. The curvature is simply the reciprocal value of the radius of curvature, and is only a comparative means of measurement. The radius of curvature of an ellipse at the end of its short axis is $\dfrac{a^2}{b}$, from which formula (6) may be derived directly by introducing the values of a and b from equations (3) and (4).—EDITOR.]

Having now found the radius of curvature of the ellipse at E, we proceed to find the number of teeth which a spur gear of that radius would have. From the figure we have:

$$AB = \frac{P_n}{\cos a} \qquad (7)$$

Now, if AB be multiplied by the number of teeth of the spiral gear, we shall obtain a quantity equal to the circumference of the gear; that is:

$$A\,B \times N = \pi\,D_1, \text{ and, since } A\,B = \frac{P_n}{\cos a} \text{ from (7),}$$

$$\frac{P_n}{\cos a} \times N = \pi\,D_1 \qquad (8)$$

Since N_c is the number of teeth which a spur gear of radius R would have, then,

$$N_c = \frac{2\,\pi\,R}{P_n} \qquad (9)$$

In equation (9) the numerator of the fraction is the circumference of the spur gear whose radius is R, and the denominator is the circular pitch corresponding to the cutter.

From equation (6) we have:

$$R = \frac{D_1}{2\cos^2 a}$$

Substituting this value of R in (9), we have:

$$N_c = \frac{2\,\pi\,D_1}{P_n \times 2\cos^2 a} \qquad (10)$$

From equation (8) we have:

$$D_1 = \frac{N\,P_n}{\pi\cos a} \qquad (11)$$

Substitute this value of D_1 in equation (10) and we have:

$$N_c = \frac{2\,\pi\,N\,P_n}{2\,P_n\,\pi\cos^3 a}$$

or

$$N_c = \frac{N}{\cos^3 a} \qquad (12)$$

* * *

The use of wind-mills for electric power generation for agricultural and industrial purposes has greatly increased in Denmark during the past years. The Danish Government conducts experiments to ascertain the best forms of installments, and since 1897 has spent about $28,000 for such experiments, and has lately erected an experimental station for determining the best means for generation of electricity by means of wind-mills. Wind-mills with four wings, have been found to be the most economical, because of giving the most power. The results have shown that out of a wing surface of about 65 square feet one horse-power is developed at a wind velocity of 20 feet per second. At a velocity of 26 feet, one horse-power is developed from about one-half of this wing surface. It is stated that 30 larger and smaller wind-power electrical installations are now in operation in Denmark.

* For additional information on this and kindred subjects, see the following articles previously published in MACHINERY: A Method of Procedure in the Design of Helical Gears, May, 1906; Cutting Spiral Gears, October, 1905; Spiral Gears, September, 1903; Spiral Gearing Helps, November, 1901.

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RACK-CUTTING MACHINES IN THE SHOPS OF THE R. K. LE BLOND MACHINE TOOL CO.

One of the lines of manufacture of the R. K. LeBlond Machine Tool Co., Cincinnati, Ohio, is the cutting of racks for the trade. Though the machines for this work have been built at home, they do not display any of the usual crudities of home-made tools, being first-class examples of machine design, presenting a number of points of novelty and interest in their construction. Through the kindness of Mr. Wm. F. Groene, the chief draftsman of the firm, we are enabled to show photographs and details of the latest of these machines, which have recently been completed and put in operation.

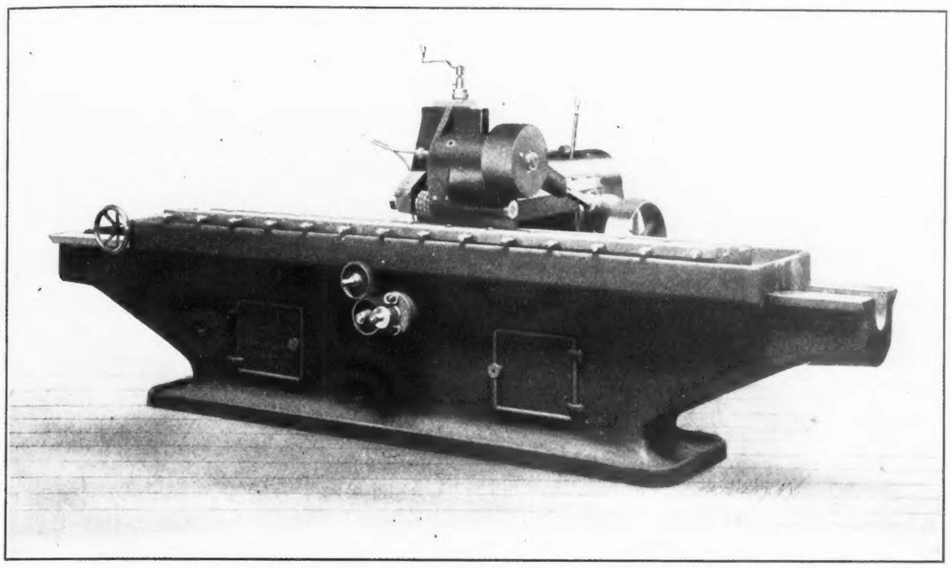


Fig. 1. Rack-cutting Machine built in the Shops of the R. K. Le Blond Machine Tool Co.

General Construction.

As may be seen in Figs. 1 and 2, the machine is of the type derived from the shaper, so far as its structural features are concerned. The cutter spindle and driving gears are carried in a head which is vertically adjustable on the front of a horizontal ram. This vertical adjustment is used for setting the cutters to depth. The horizontal ram is fed slowly forward for the cut, and is then rapidly returned while the work is indexed to a new position. The work is held in a long vise attached to the top of a work table, sliding on dove-tail ways on the long base of the machine. This base, as may be best seen in Fig. 2, is of T-form, having a rearward extension to support the ram, and it is cast solid in one piece. The machine is fully automatic in all its actions.

A 5-horse-power motor, mounted on the ceiling, drives the machine through a single speed pulley, shown best in Fig. 2. The single speed shaft, through change gearing in the case at the right of the ram in Fig. 2, drives a second shaft, connected by bevel gears with the splined shaft shown, running diagonally upward to the cutter slide, where the motion is transmitted to the cutter spindle through bevel and twisted tooth gears. This arrangement of splined shaft and bevel gears transmits the power without interfering with the movements of the cutter ram. The automatic slow forward feed and quick return of the ram is effected by mechanism in the casing at the rear of the column, as shown in Fig. 2, controlled by the handle projecting through the back end of the ram.

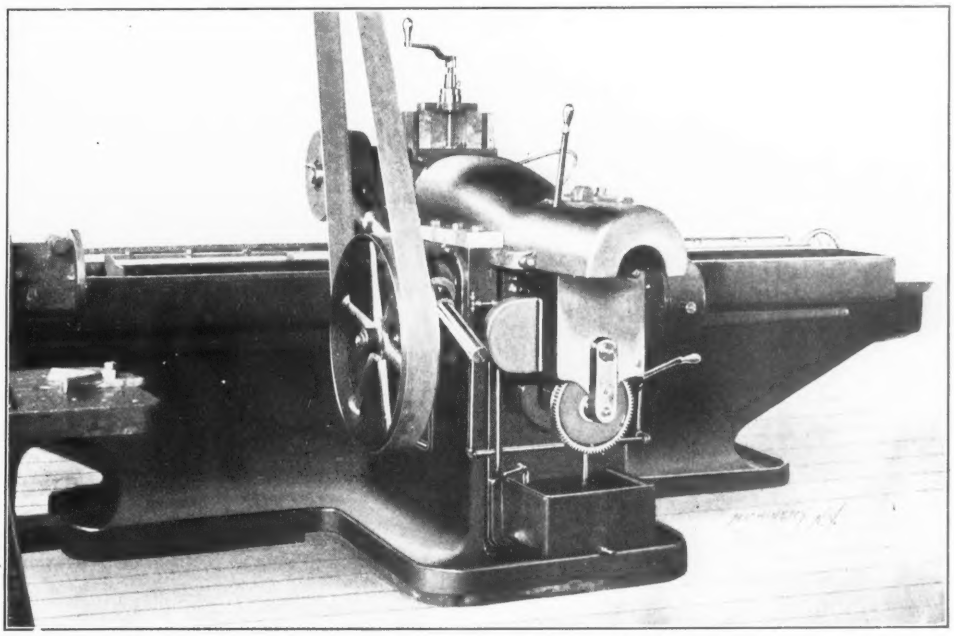


Fig. 2. Rear View of Rack-cutter, showing Driving Mechanism.

The indexing is controlled by change gears at the front of the bed.

The work table is indexed by change gears mounted at the front of the bed. The movement of the table for indexing is effected by a stationary lead-screw carried by the table, and a revolving nut operated by the indexing mechanism. The machine will cut racks 10 feet long at one setting. Racks longer than this can be cut by resetting in the chuck, the table being provided with a fine micrometer adjustment by means of the hand-wheel shown at the left in Fig. 1, whereby it can be moved independently by the indexing mechanism, for matching the teeth. The return of the table for the next setting of the rack, and all other movements of the machine, are power operated, relieving the operator of all physical effort. These provisions make it possible for one man to run four machines.

To insure the maximum of productiveness from the machine, provision has been made in its design to furnish an abundant supply of oil to the cutters, so that the work and the cutters are flooded with a stream of lard oil. The inside of the column forms a reservoir from which the oil is pumped to the work. The machine has the necessary arrangements for straining and returning the oil to the reservoir.

Spindle Driving Mechanism.

Details of the spindle drive are shown in Fig. 3. The driving bevel pinion, mounted on the end of the splined driving shaft shown in Figs. 1 and 2, drives a bevel gear keyed with a taper fit to the driving pinion shaft. This shaft has teeth formed integrally with it, meshing with the intermediate gear shown, which, in turn, meshes with the pinion teeth formed integrally with the cutter spindle. This gearing has helical teeth, to give a smooth, even drive to the cutter spindle. The difficulty of driving the spindle of the rack-cutter is well known. The difficulty arises from the fact that the driving pinion of the cutter spindle must be smaller in diameter than the cutters which it drives, so that it must necessarily have very few teeth and be subjected to great strain. This makes it difficult to make it strong enough, and at the same time give a smooth, steady drive. In this case the teeth are made strong enough

by being given a very wide face (5 inches), and the required smoothness of drive with the large pitch used is effected by making the gears with twisted teeth, the helix angle being 14 degrees. The end pressure produced by these twisted teeth is taken care of by suitable thrust washers, the direction of pressure being toward the left for the driving pinion and the cutter spindle, and toward the right for the intermediate gear stud.

The bearings for the cutter spindle on each side of the pinion are tapered, as shown. The one at the left, which takes the thrust, is held in the cutter slide by taper dowel pins. The one at the right may be screwed in or out of the cutter slide cup to take up end play. At the extreme left, the spindle is supported by a removable outboard bearing, which

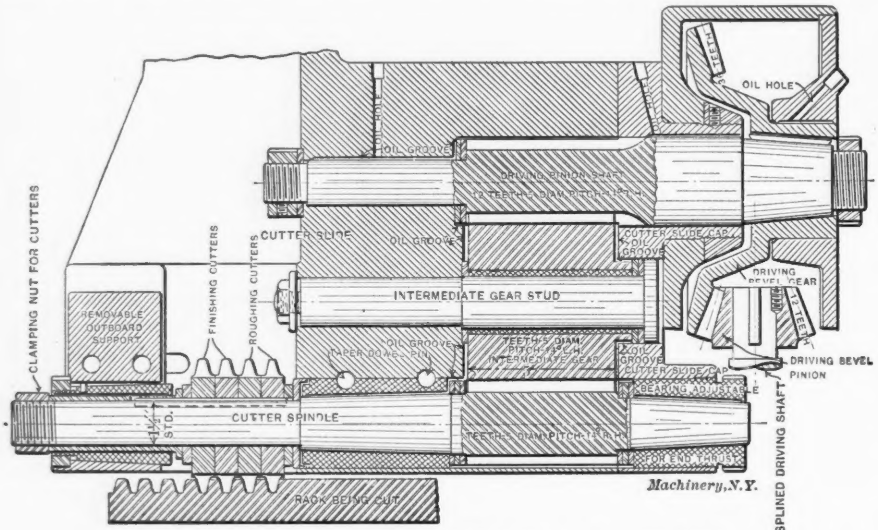


Fig. 3. Vertical Section through Cutter Spindle and Driving Gears.

slides off endwise, and may be adjusted longitudinally to accommodate the width of cutter space required for the cutters used. In the drawing, four cutters are shown in place, two of which rough the tooth spaces while the other two finish them, thus completing two teeth complete at each feeding stroke of the ram. These cutters are keyed to the spindle and are clamped by the nut at the outer end of the spindle, through the journal bushing shown. This bushing has a bearing in the outboard support. The box for this bearing is tapered and split so that it may be adjusted for wear.

Accuracy of Product.

Special attention has been paid to the accuracy of the product. The automatic indexing of the table gives more accurate and uniform results than hand indexing, and this accuracy is still further assured by the mechanism provided for locking the table in position after it is indexed. The great weight (about six tons) and stiffness of the machine also tend in the same direction.

Tests of the accuracy of the indexing were made by placing a 10-foot length of stock in the machine and milling teeth in it for its full length. The cutter used, to facilitate testing, was an ordinary half-inch slotting mill, cutting square teeth. The machine was set to index three diametral pitch, which is about 1.0472 inch circular pitch. The rack was then measured for every 6 inches throughout its length with a Brown & Sharpe 24-inch vernier caliper, set to cover 22½ teeth; that is, 22 teeth plus the thickness of a tooth. The space being 0.5000 inch thick, and the tooth 0.5472 inch thick, this gave a calculated distance of 23.5856 inches for the calculated setting of the vernier. In the 16 measurements made throughout the length of the 10-foot rack, the actual settings obtained varied from the theoretical by from 0.007 inch above to 0.0025 inch below, these amounts being the error in about 2 feet. It is believed that these tests show accuracy meeting every commercial requirement.

One source of error ordinarily met with in rack-cutting machines has been avoided in this tool. Ordinarily, the lead-screw is of some even number of threads or turns per inch. This makes it possible to figure out the gearing for circumferential pitches very easily. For diametral pitch racks, however (which constitute by far the greater part of the product of any such machine), translating gears have to be used to take care of the factor π, which must be used in obtaining diametral pitch from circular pitch measurements. The usual ratio used is 22 : 7, which, carried out, gives a value for π of 3.1429, considerably larger than the true value. From this it follows that racks cut with this gearing are uniformly longer for a given number of teeth than they should be, the error amounting to about 0.0046 inch per foot in length—not enough to create any serious difficulty, of course.

In the present machine this error has been avoided by making the screw with a special lead of $\pi/3 = 1.0472$ inch. The gearing for cutting this special lead was very carefully calculated, the actual calculated pitch for the gearing used being 1.04724 inch lead. This makes the screw nearly correct for diametral pitch gears, while the translating error involved in using the 22/7 ratio will come in cutting circular pitch gears, which form but a small part of the machine's output. The fact that the pitch in the test showed average measurements slightly greater than the standard, is perhaps due to heating, or some other similar cause.

The cold rolled stock ordinarily used for racks comes from the rack-cutting machine somewhat bowed, owing to the removal of the skin tension on the outer surface by the cutting operation. These racks are straightened by passing them several times through a machine which rolls them back to their proper shape. This machine has been specially designed for the purpose, and the straightening is accomplished without impairing the accuracy of the teeth in any way. This straightening machine was illustrated and described in the December, 1906, issue of MACHINERY.

* * *

CONCRETE FOUNDATIONS FOR DROP HAMMERS.

At a recent visit to the Pratt & Whitney Co.'s shops at Hartford, Conn., the writer had an opportunity to see some very interesting drop hammer foundations, made from solid concrete. The blacksmith shop is located on what one might say is the second floor of the building, there being a basement about 11 feet high under the blacksmith shop, which is used as a stock-room and where the case-hardening furnaces are located. The foundations for the drop hammers in the blacksmith shop must therefore be carried down clear through the basement, and then down approximately another 11 feet to hard pan. The construction of these concrete foundations is shown in Fig. 1. At A is shown a cast iron base-plate, into which the base of the drop hammer sets. This plate is bolted to the concrete column by four 1¼-inch anchor bolts. Between the cast iron plate and the top of the column a double layer of wood and also a thick layer of tar paper are interposed, the purpose of which will be referred to later. The column, as shown, reaches nearly up to the ceiling of the basement, C being the floor line of the blacksmith shop. At D is shown a line representing the floor of the basement. As will be seen, reinforcements have been placed around the concrete column in the form of heavy planks B, having one-inch bolts through the concrete to clamp them up against the concrete surface. It has been found later, however, that this reinforcement was not necessary, and that the foundations would have served their purpose fully as well had the column been left plain all the way down.

The installation of these concrete foundations, as compared with the wooden foundations previously used, has proved to be a very economical move. While previously, with hammers working on wooden foundations, it was not possible to make the drop forgings shown in Fig. 2 on anything but a 200-pound

hammer, since these foundations were put in, it has proved possible to make them on a 100-pound hammer, and, at the same time, the rapidity of completing the drop forgings has been increased, so that a saving in time of 20 per cent has resulted in the making of these forgings. Other elements of saving in comparing the making of these forgings on a 200- or a 100-pound hammer are that the tools cost more for a larger machine, and it consumes a great deal more power. The reason why there is a saving in the making of these forgings, even in regard to the time consumed, is because the strokes, even on a smaller hammer, can now be made shorter, so that a greater number can be struck in the same time, the blows, however, having an equally good, or better, effect, on account of the solid foundations under the base of the hammer. In the case of drop hammers, where the hammer was previously raised three feet, it is now not necessary to raise it more than two feet, in order to accomplish the same results.

When the foundations were first put in, the cast iron plate *A*, already mentioned, was laid directly on a surface of cement, three inches thick, placed on the top of the concrete foundations. The cast iron base-plate, of course, was not finished on the bottom, but was more or less rough. The cement itself did not have a perfectly plane surface, and it was found that, after the hammer had been used for some time, the top layer of the cement would be ground to powder, on account of the rough surfaces coming in contact, constantly cutting and grinding the surface of the cement. In

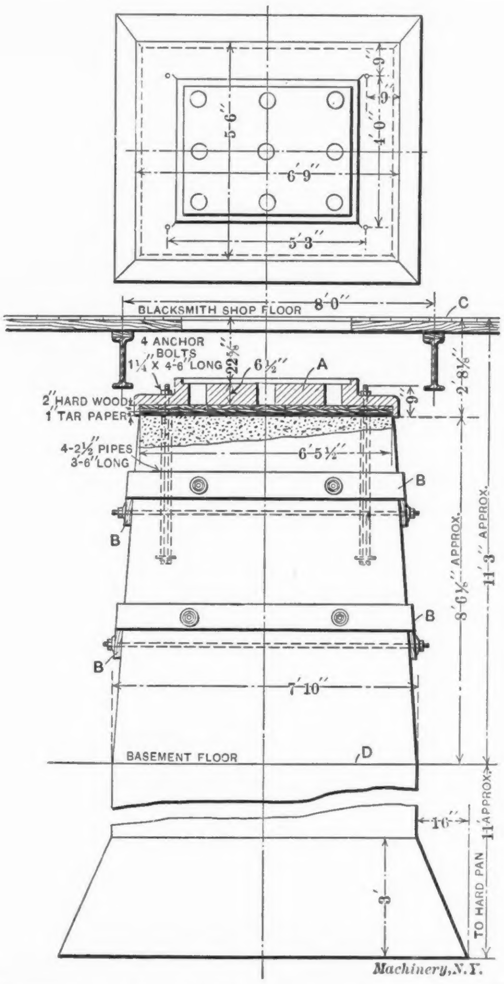


Fig. 1. Concrete Foundations for Drop Hammers in the Pratt & Whitney Co.'s Blacksmith Shop.

order to prevent this, a layer of tar paper, one inch thick, was first placed on the top of the concrete foundation, and on top of this, two layers of hard wood, each one inch thick, were laid diagonally, the cast iron base-plate being placed directly on the hard wood, after which the anchor bolts were tightened down, clamping the base-plate tightly against the wood and the tar paper, and consequently pressing the latter firmly against the top of the concrete. The tar paper would fill in all crevices and rough places on the top of the concrete, and the impact of the hammer blows would be distributed equally over the whole surface. After this improvement had been made, no more troubles were experienced with the top of the concrete being pulverized by the blows of the hammer.

At first it was feared that these solid foundations, having practically no springing action whatever, would cause trouble in regard to the dies, so that a greater cost would be incurred in regard to the replacing of broken dies, but this apprehension proved to have no foundation; the dies seemed to stand up fully as well now as with the old wooden foundations.

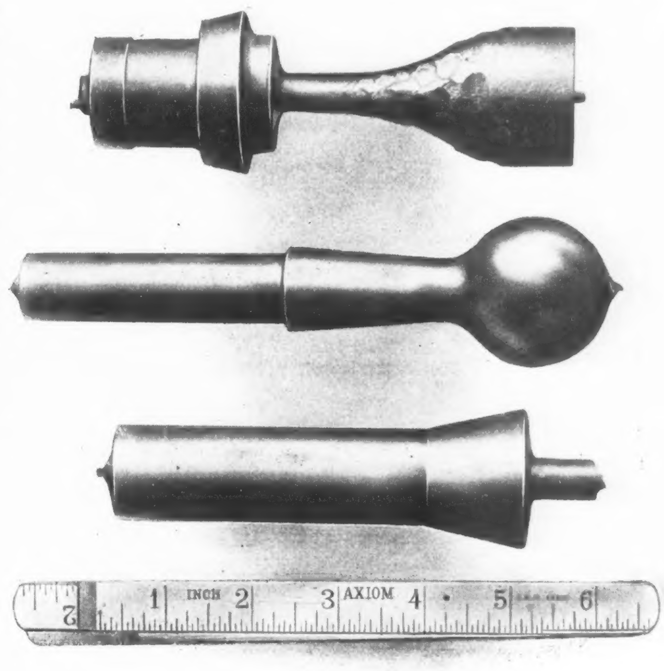


Fig. 2. Examples of Work formerly done on a 200-pound Hammer, but with Concrete Foundations completed on a 100-pound Hammer.

The concrete used for these foundations is what is known as 1—3—5 mixture. This mixture consists of one bag of cement, one barrel of heaped sand, and two barrels of stone.

In conclusion, it may be well to remark that the examples of drop forging shown in Fig. 2 do not, by any means, represent the limit of what could be made under the 100-pound hammer since the concrete foundations were put in, but the dimensions of these pieces are now limited by the size of the dies that can be placed on the hammer. As far as the power of the hammer is concerned, it would be possible to forge pieces probably 25 per cent larger than those shown.

The type of foundation used before these concrete columns were put in is shown in Fig. 3. On these foundations the base-plate was first laid on a few layers of plank, each layer being placed crosswise in relation to the next layer above, and this, in turn, was carried by timber, standing on end, to reach through the basement of the building. This timber, in its turn, was placed on foundations in the basement floor. Iron bands reinforced and held the timber together. This built-up foundation, however, acted as a buffer, and the timber standing on end was actually compressed several inches yearly, due to the force of the blows of the hammers.

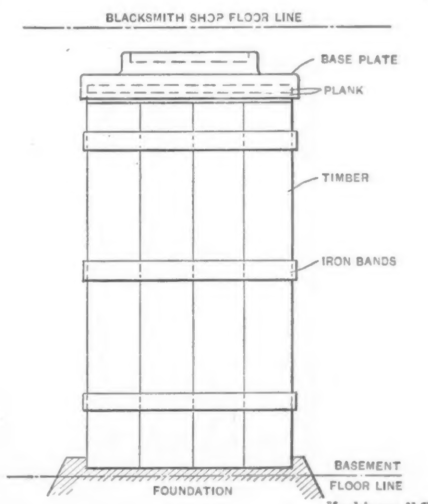
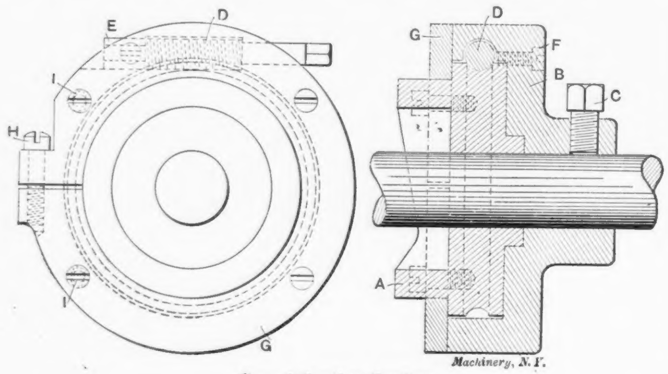


Fig. 3. Old-style Wooden Foundations which have been replaced by the Concrete Column shown in Fig. 1.

LETTERS UPON PRACTICAL SUBJECTS.

CAM ADJUSTING DEVICE.

Some time ago we had a great deal of trouble with the setting of the cams on our automatic roughers. Sometimes it was but a matter of a few minutes to get them just right, and again it would take over an hour of hard work and strong language. To remedy this state of affairs, we installed a series of cams such as shown in the accompanying cut. The cam proper is shown at *A*, enclosed by the circular housing *B*, which is secured to the shaft by the set-screw *C*. The housing *B* is provided with bearings for the worm *D* which engages with the worm threads cut on the cam member *A*, as shown. The worm *D* butts against a shoulder in the housing *B*, and is held in place by a plug bushing *E* driven in at the other end as shown. This plug is held tightly in place by the screw *F*. At *G*, finally, is a split steel ring fastened to the housing *B*, thus holding cam *A* firmly in place.



Cam Adjusting Device.

After the cam has been approximately set in place and secured by tightening the screw *C*, the next step is to loosen the binder *H* and the two screws *I*. These two screws work in slightly elongated slots, and when loosened allow the ring *G* to spring open a trifle. This leaves cam *A* free to revolve, and it is then adjusted accurately by means of a socket wrench fitting on the squared end of the worm shaft *D*. When the adjustment has been satisfactorily made, the binder *H* is tightened, thus drawing the ring *G* around *A* and clamping it. Screws *I* are then screwed down, and this serves as a further lock against the ring loosening. The cam is then in condition for service. With this arrangement it was possible to adjust the cams to the finest required degree of accuracy, and since placing them on the machines we have had no further trouble along this line. F. B.

MILLING ATTACHMENT FOR THE LATHE.

The accompanying half-tones, Figs. 1 to 3, show a simple but efficient milling attachment for the lathe. This device

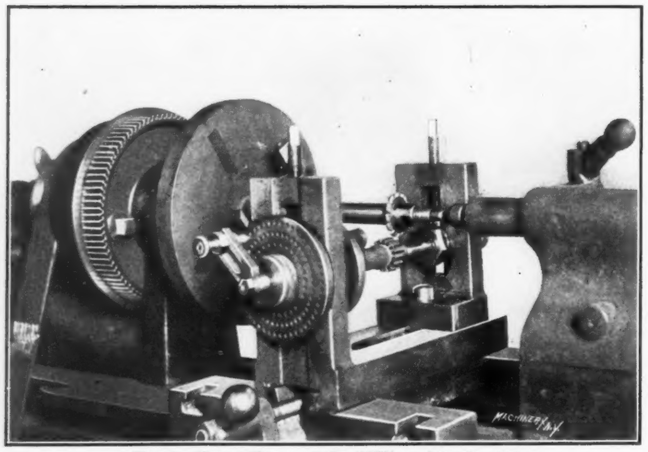


Fig. 1. Front View of the Milling Attachment.

is in use on a foot-power lathe in the private little workshop of Anton Schuermann, of Decatur, Ill., fitted up in the garret of his home.

Fig. 1 shows the front view of the milling attachment, and Fig. 2 shows a rear view of the device, both when in place in the lathe. The gear shown on the arbor between the centers of the device has actually been milled in the foot-power lathe with this device. As will be seen from the cuts, the attachment is placed on the cross slide, in place of the tool carriage. The general design of the device is most plainly

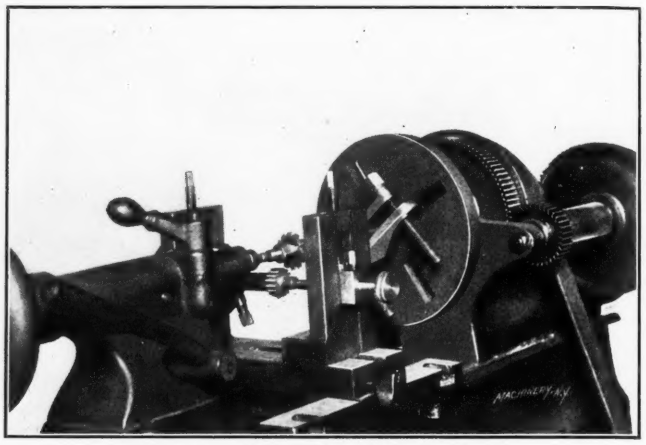


Fig. 2. Rear View of the Milling Attachment.

shown in Fig. 3. The screws *A* are adjusting screws, used for raising and lowering the head- and tail-centers, working on the same principle as does the Lincoln milling machine. The nuts *B* are lock nuts, which are loosened before the screws *A* are turned for adjusting the heads. The tail-center *F* simply slides back and forth in its bearing in the tailstock, and is held in place by a set-screw *G*. The whole tailstock may be moved in and out by loosening the screw *K*. The index dial is shown at *D*, three different dials being used

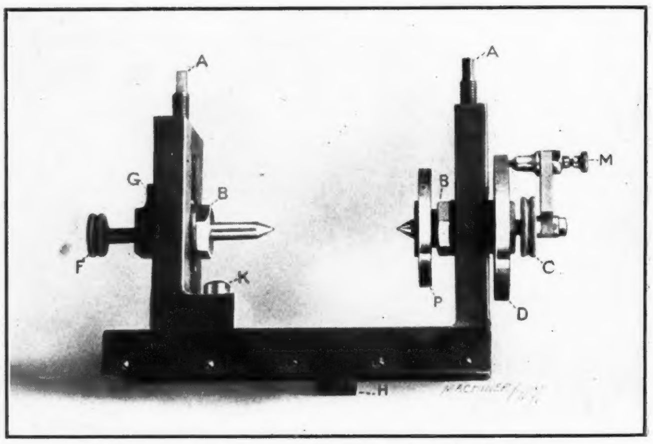


Fig. 3. View showing the Simplicity of the Design.

with the device. The spacing arm *M* is securely locked wherever set by the knurled thumb-nut *C*. The nut by which this fixture engages the cross-slide screw, is shown at *H*. In order to prevent play when an arbor is held between the centers, the tail of the dog used is made tapered where it enters the slot of the driving plate *P*, so that it will fit snugly.

The writer has seen a number of milling attachments adapted to lathes, but this one has several features which are superior to any that he has seen so far. ETHAN VIALL.

Decatur, Ill.

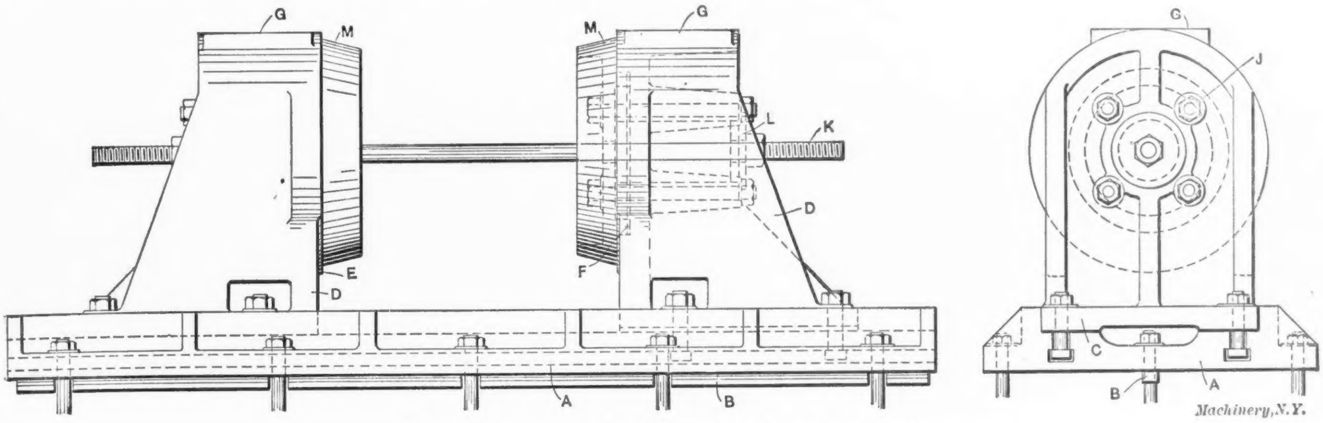
PLANER CHUCK.

Some time ago it became necessary to do some very accurate planer work on a number of cylinders, insuring that the seats outside be true with the center of the bore, and therefore an improvement was necessary on the chuck originally used for that purpose. The outcome of the redesigning was the chuck shown in the accompanying cuts.

The original form of chuck for this class of work consisted of two standards which were bolted to the table of the planer and provided with a series of interchangeable cones, each held by a central bolt to its own standard. This form of chuck rendered it very difficult to get the axes of the two cones

in the same straight line. The chuck, as shown in the cuts herewith, was found upon trial to entirely obviate this difficulty.

The first point at which it was found necessary to change the construction was that a false table had to be constructed to fit upon the planer table. This table is indicated by the letter *A*, Figs. 1 and 2. The rough casting for this table was first of all planed true on the bottom surface. The table of the planer to be used was planed off and the center slot of the table cut out parallel throughout its length by a tool held directly in the tool-post. The false bed was provided with a rib *B*, Figs. 1 and 2, which was accurately finished to fit the slot in the planer table. The false bed was then securely bolted in its permanent position on the table, and a way planed as shown at *C*. This way was carefully finished both on the bottom surface and on the two sides, so as to be of even width throughout.



Figs. 1 and 2. Side and End Elevations of the Planer Chuck.

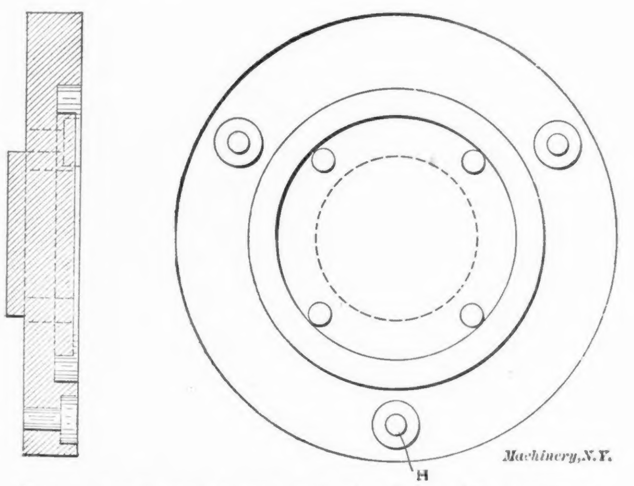


Fig. 3. False Face-plate used for Turning Cones of Various Sizes.

The standards *D* had their feet finished accurately to fit this way, both standards and way being scraped to a sliding fit. When the standards were placed on the way, the centers for the cones were very carefully laid out and tested to insure the two centers being exactly in line. The standards were then removed, chucked in a lathe so that the center was truly central with the spindle of the lathe, faced, and the annular groove *F*, Fig. 1 and 4, accurately turned. The standards were then replaced on the planer and a spot planed at *G*, Figs. 1 and 2, on each one, this spot being an even number of inches above the center line of the cones and center of the annular groove *F*.

Since the cylinders which were to be faced in this chuck were of varying sizes, it was essential that a number of different sized cones should be used to accommodate the various bores. For this purpose the face-plate on a heavy lathe was bored out to receive the boss of the false plate shown in Fig. 3. This false plate was provided with three tapped holes *H* to agree with holes near the rim of the regular face-plate. The false face-plate was made by chucking it with the boss outward in the lathe, and facing off the back, and forming the boss. The face-plate was then turned over and the annular recess shown was cut in it to agree accurately with the recesses *F* formed in the standards. The holes *H* which are countersunk for tapped bolts to enter tapped holes in the regular face-plate should not be spaced evenly, as it is essential that the false plate should have the same position on the regular face-plate every time it is used.

The cones *M*, Fig. 1, were prepared from the rough casting by having an annular rib accurately turned on the back and the back faced off while the casting was held in an ordinary chuck, the rib being made to templet so as to fit either the false face-plate, or the standard. The cone was then bolted to the false face-plate in position on the lathe, and the conical surface carefully turned. It will be seen that an exact center was thus obtained with the center of the false face-plate, which in turn was truly central with the lathe centers, and it was thus possible to get out any number of various sized cones, the centers of all of which when applied to the standards would lie in the same line.

It will be noted in Fig. 4 showing a horizontal section through one of the standards and its cone, that clearance is allowed between the annular rib and the recess receiving it, and that clearance is also allowed between the face of the standard and that part of the back of the cone lying inside of the annular rib. The purpose of this was to obviate the necessity of finishing the back of these portions, as the surfaces obtained by the sides of the rib and the back of the cone outside of that rib are amply sufficient to carry all the stress arising from the weight of the cylinder when in position.

By reference to Fig. 4, it will be seen that the central part of the standard is cast with a large opening clear through;

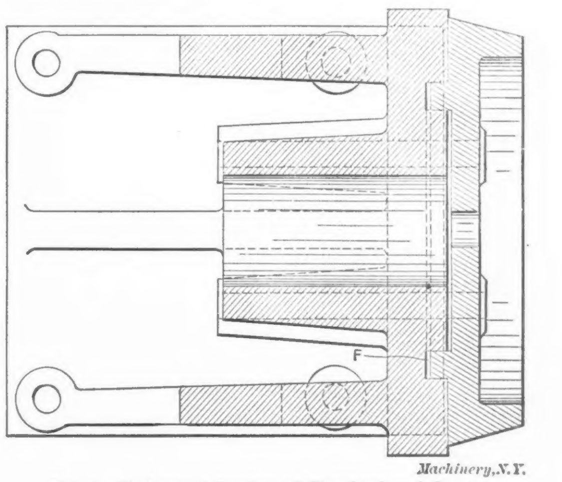


Fig. 4. Horizontal Section of Standard and Cone.

this is merely for lightness, and because in this particular case the cylinders to be carried were very heavy, these standards, if cast solid, would be very difficult to move. The cone is held to the standards by four bolts *J*, Fig. 2, and when in position on the false face-plate for turning, four tapped holes are provided in that face-plate to receive bolts to hold the cone securely. Adjustment for length is made by means of the threaded bar *K*, provided with necessary nuts, and having washers *L* fitting the openings above referred to in the standard.

After having tried this fixture, it was decided to provide means whereby two cylinders could be planed at the same time. A standard having two faces and with two cones was placed between the other two standards, and the bar *K* lengthened. As the construction of this standard, however, is so nearly the same as the ones described, it is not deemed necessary to go into the detail of it.

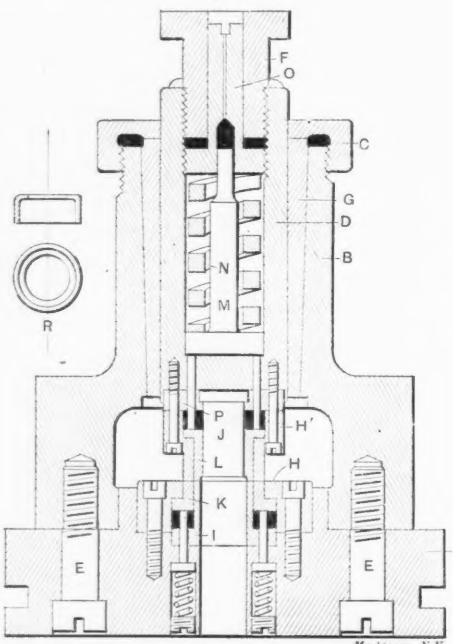
The face *G* is used for leveling up the cylinder cross ways, only the longitudinal leveling being accomplished by the cones. This, of course, is easily done by means of a surface gage, since the face *G* is horizontal both transversely and longitudinally, and is also parallel to the center line of the cone. It is, of course, obvious that the bolts may be changed to suit the planer on which this device is to be used and it is also plain that if a center slot is not obtainable in the planer table, two side slots may be used and two ribs like *B* provided.

Richmond, Va. L. N. GILLIS.

PUNCH AND DIE FOR BLANKING AND FORMING COPPER CUPS.

The subject of punches and dies has been gone over so thoroughly, and is so well understood, that it may seem a bit superfluous to add anything to it; nevertheless the accompanying illustration may be of interest to those who come in contact with such tools.

This die is designed to blank and form up a copper cup or capsule used in the manufacture of balance wheels for watches. The copper strip is fed into the press, which then blanks out and draws the metal into the shape shown at *R*, at the same time punching the center hole. Referring to the



Punch and Die for Blanking, Piercing, and Forming the Copper Capsule shown at R.

illustration, *A* is the base of the sub-press, *B* the body, *C* the cap, and *D* the plunger; all these being of cast iron machined to size. The body and base are held together by two screws *E* after the usual well-known manner. *F* is the buffer plug which receives the thrust of the press piston, and *G* is the babbitt lining of the body *B*. *H* is the outside diameter die, held in place by four screws and two dowel pins. *H'* is the outside diameter punch, also held in place by four screws and two dowels. *I* is the die for cutting out the center hole, and *J* is the punch for this hole. *H'* and *I* also serve as forming dies in bringing the metal to the proper shape. *K* and *L* are shedders, supported by four push-pins, those of the former resting upon springs whose tension is controlled by short threaded plugs, as shown, and those for the latter abutting against the piston *M*, which is in turn pressed down by the large spring *N*, the tension of which is controlled by the plug *O*. The block *P* is used merely to hold the punch *J* firmly in place.

The operation of the die is as follows: The press ram being at top stroke, the copper strip is fed in across the top of *H*, and as the ram descends, the blank is cut from the strip by the punch *H'* and drawn to a cup shape between the inside edge of *H'* and the outside edge of *I*. Simultaneously, the center hole is punched by *J* and *I*. As will be seen by referring to the illustrations, *J* is made a trifle short so that the drawing operation will have begun before this hole is punched. This prevents any distortion of the piece by the punch *J*. Some little trouble was experienced at the start on account of the air in the hollow plunger *D* forming a cushion when it was compressed by the rising of the piston *M*, thus preventing the proper working of the die. This was finally obviated by making a small groove at the side of the piston where it worked in the plug *O*, and drilling a vent hole through *O* as shown. This allowed free communication to the atmosphere, and from then on the die gave complete satisfaction. The variation in size among the cups, or capsules, as they are called, is never more than 0.001 of an inch either in diameter or in length. B. W. F.

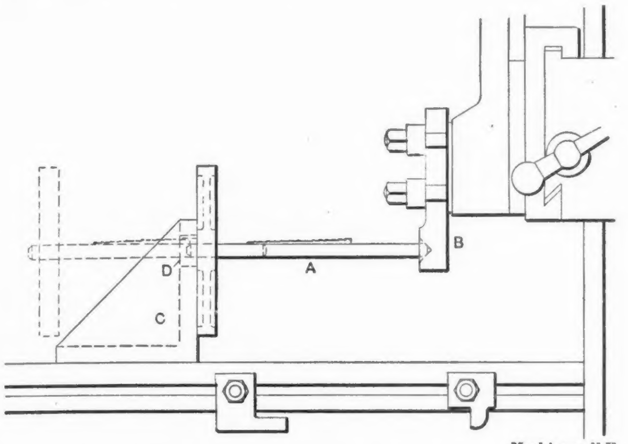
MACHINING CHANGE GEARS.

A subject which is of importance to all lathe builders, whether they be manufacturers who turn out two or three machines a day, or the smaller concerns who may finish the same quantity in a week, is the machining of the change gears. In England this is more important than in America, because the man who first supplied England with screw-cutting lathes decided that twenty-two change gears were necessary, and so twenty-two change gears have become the standard complement, while the ordinary American lathe, as far as my experience goes, has only about fifteen or sixteen. I have not been able to put all the following ideas into practice, but where circumstances permit I shall try all those that are most suitable. I should also like to know from some of the firms who have a lot of this kind of work, how they do it, and the time taken, as this is not so much a record of actual work as a few suggestions as to how the work might be done.

The first item is the castings; start with good workable castings. It will pay to give a bit extra for decent castings. Pickling will improve their workability, and annealing is still better, though perhaps too expensive. The machining of the blanks is the most expensive point of the whole job, with the possible exception of the cost of the castings, therefore it seems that this is the place where we ought to make the biggest saving. One method is first to bore and ream the hole, then drive onto an arbor, and turn down the faces of the rim and boss, using a tool at each side. After this has been done, the blanks are mounted on an arbor, five or six at a time, and the outside diameter turned. I don't care much for this method of turning the sides, because I think there is a tendency for the blank to slip on the arbor when the cut is on, so that the size and speed of the cut will have to be adapted to the gripping power of the arbor, and though two tools are in operation and balancing each other as far as the spring sideways is concerned, there will require to be twice as much power transmitted through the arbor. The method I should adopt for this work would be as follows: There would be a turret mounted in place of the tail-stock, carrying four tools, that is, a chucking drill, a single point boring tool, a roughing reamer, and a finishing reamer. This turret would be fed forward by hand by means of a large pilot wheel, and would revolve automatically on the back stroke. The reason why I should have a hand feed is because the operations would be so quickly performed (especially if the tools were high speed steel) that an automatic feed which would have to be engaged every time would not appreciably diminish the time, though a full automatic turret would no doubt be beneficial. To turn the sides, there would be a long tool-holder mounted on the carriage cross slide, and hinged thereto, so that it could be lifted up to clear the turret when the turret was in operation. Two tools would be used, one for the rim and one for the boss; they would be set in the same plane, so that the boss would be the same length through it as the width of face of the teeth, when machined. The reason for this will be explained later. It will be seen now that there are two tools in operation at once, just as

in the other method, and the gear, being gripped in the chuck and thus supported at four points of the rim, is in a better position for being machined than when mounted on a comparatively small arbor. After one side has been machined, the gear is turned around and without any particular care in setting true, other than getting it flat against the faces of the jaws, the other side is machined in a similar manner. The outside diameters are turned as in the first method.

I might say for the benefit of American readers that in England an 8-inch center (16-inch swing) lathe would be supplied with twenty-two change gears, having from twenty to



Machinery,N.Y.

The Way in which the Gears are key-seated on the Planer.

one hundred and twenty teeth, with an extra 40-, 50-, or 60-tooth gear. They would be 8 diametral pitch and 1¼ inch bore, so that it will be seen that turning up the 120-tooth gear, which is 15¼ inches diameter, on a 1¼-inch arbor is not by any means a rigid job. Another method of machining the blanks, which I think would make about the best time of any, is by grinding. A powerful grinder would soon grind the comparatively narrow faces of a change gear, and leave a better finish than could be obtained by turning and polishing. I should think the Landis Tool Company ought to be able to give us some interesting information on this subject.

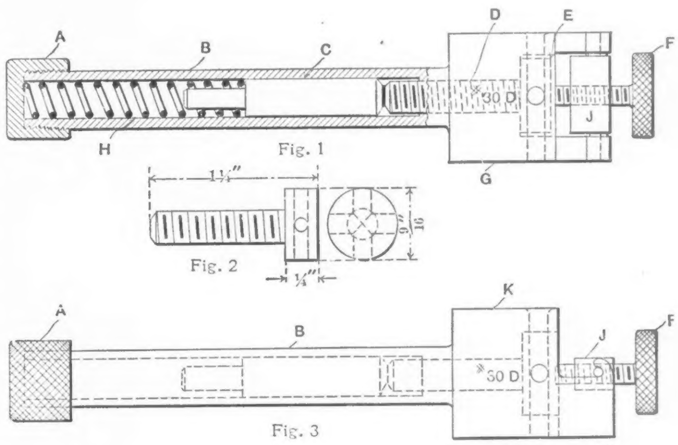
The next question is the cutting of the gears, and I can speak definitely on this point. It is possible to cut 8-pitch teeth in cast iron at a feed of ten inches per minute, and by this I don't mean for five minutes, but day after day, week in and week out. I have done this myself. The machine used was a Brown & Sharpe No. 6; the speed, fifty revolutions per minute; the cutter, a Cammell Laird 0172 high speed steel, 4 inches diameter, and the feed 0.2 inch per revolution. The blanks are cut six at once, and it is for this reason that the rim and boss are made level, the blanks thus staying each other. The indexing motion is geared up, not to cut consecutive teeth, as usual, but to pass two or more teeth, according to the number being cut. For a 120-tooth gear, we arrange to cut every seventh space because 2, 3, 4, 5, and 6, being factors of 120, would simply divide the gear into 60, 40, 30, 24, and 20 respectively; whereas, when we cut every seventh tooth, the cutting goes on until the gear is finished, the blank going around seven times. It is really wonderful how this simple proceeding dissipates the heat generated by the cutter, both cutter and blanks being comparatively cool after a two hours' run, the time usually worked with one sharpening of the cutter.

To finish the gears, they require to be key-seated, and for this a planer can be used, which, with very little outlay, will make as good time as the best key-seater. The first thing to be considered is the cutter bar or broach, which consists of a piece of tool steel *A* about twenty-four inches long, and a sliding fit in the bore of the gears. This bar is grooved to a depth of about three-eighths of its diameter, starting in at one end and finishing about three inches from the other end. Into this groove are fixed, by screws from the under side, two or three pieces of tool steel which have teeth cut therein, the teeth tapering from nothing at the front end to the depth of the key-seat at the other end, the last few teeth being all the same height so that they will keep the size longer. The first tooth is about two inches from the front end of the bar. The width of the teeth is of course equal to the width of the key-seat to be cut. To the planer tool-post is fastened a suitable cup-shaped thrust piece *B*, and an angle plate *C* is securely bolted to the platen. In the angle plate is a hole which receives bushing *D* bored the same size as the cutter bar or broach. In operation, the planer platen should not run above 15 feet a minute on the cut, the stroke being adjusted so that it is from 6 to 12 inches more than the length of the cutter bar. The front end of the cutter bar is then placed in the angle plate bushing, and run through two or three times, the bar being revolved the width of the key-seat at every stroke, so that there is no fear of the teeth having to cut into the bushing when operating on the gears. After this has been done, the stroke is altered so that when the table reverses at the end of the cutting stroke there is room for the gear between the thrust piece and the angle plate. It isn't necessary to stop the machine every time a gear has been key-seated. As soon as the end of the bar comes through the angle plate, another gear is put on, as indicated by the dotted line, and when the table reverses, the gear that has been key-seated is removed, and the bar with the gear which has been previously placed in position is withdrawn and put on the other side of the angle plate to be again pushed through. It is necessary always to keep the teeth of the cutter-bar approximately in the same position as the slot in the bushing. With this arrangement it is an easy job to key-seat one hundred and twenty gears an hour, the biggest job being the carrying of the gears to and from the machine.

RACQUET.

DRILL JIG.

Figs. 1 and 3 represent a drill jig for drilling ⅛-inch holes in the adjustment screw shown in Fig. 2. This screw is made from cold rolled stock, and the holes do not need to be very accurate, as they are only used to turn the screw by putting a pin in the holes. Referring to Fig. 1, handle *B* and the body of the jig *G* is made from a piece of square machine steel and case-hardened. The piece of work to be drilled as shown



Machinery,N.Y.

Figs. 1, 2 and 3, showing the Jig and a Sample of the Work.

in Fig. 2, is placed into the jig and held there with the thumb and the left hand, pushing back plunger *C* against spring *H*, while cross-head *J* with screw *F* is taken in the right hand. The cross-head is placed in position as shown in Fig. 3, hooks on the jig body being provided for the pin through the cross-head, and screw *F* is then tightened. Then the screw shown in Fig. 2 is ready to be drilled. It is only necessary to drill from two sides of the jig. The size of the drill is marked on these two sides.

A very important feature is that after the piece of work is drilled, and the cross-head *J* is removed, spring *H* pushes out the piece of work, and all that is necessary to do is to insert another screw, and drill in same manner as before. Cap *A* is merely to keep spring *H* and plunger *C* from coming out.

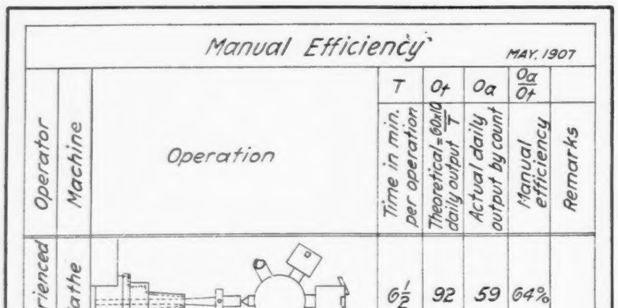
This jig was first tried with a small cam lever, instead of using the cross-head *J* and screw *F*, but owing to the variation in width of the heads of the screw (Fig. 2), it made it impossible to stop the cam lever in same position every time, which caused the lever to project past surface *K*, which of

couse, interfered in laying the jig on the table of the drill press. It may not seem practicable to make a jig and not bush the holes, but as we did not have a great many screws to drill and as the work was not very particular, it was cheaper and good enough for the job to leave out the bushings. The jig has proved very satisfactory, and has been in use at different times for more than three years, and it is still in good condition. B. M. WELLER.

Franklin, Pa.

EFFICIENCY CARD.

The accompanying cut shows a page from a data book used in one of the machine tool building shops. This card is intended for recording the time used for performing certain operations, and for recording the efficiency, expressed in per cent, of the men. In the two first columns are given the class of operator and the machine on which the operation was performed. The middle column, headed "operation," under which are shown crude sketches of the tools used, is intended to give an idea of the class of tools and the way of setting up used in the individual case for which the record was taken.



Manual Efficiency MAY. 1907

Operator	Machine	Operation	T Time in min. per operation	O_t Theoretical = 600/T daily output	O_a Actual daily output by count	$\frac{O_a}{O_t}$ Manual efficiency	Remarks
Experienced	Fox lathe		$6\frac{1}{2}$	92	59	64%	
Apprentice	Small Monitor		1	600	262	43%	
Experienced	Large Monitor		$1\frac{2}{3}$	360	154	42%	Operator complained monotony
Experienced	Small Monitor		$1\frac{1}{3}$	450	133	30%	Form tool sharpened per 12 cuts - slag in metal
Apprentice	Small Monitor		$\frac{3}{4}$	800	356	45%	
Experienced	Fox lathe		$8\frac{1}{2}$	70	41	59%	

Sample Page from Data Book in which is recorded the Time for Performing Work, and the Efficiency of the Men.

Each man is permitted to set up his work and his tools in an individual manner, using, of course, such special tools as he receives on request from the tool-room. The time given in the column T is the time in minutes used for completing one piece, the operator, unknown to himself, having been timed through one complete cycle of operation. For the sake of comparison, the number of pieces made during the day was counted after the men had left the shop. The column O_t gives the theoretical daily output, that is, the output which would result if all the pieces could be made at the same rate as the one timed in the first column. The column O_a gives the actual daily output ascertained by counting, as stated heretofore. The next column gives the efficiency in per cent, being arrived at by comparing the theoretical daily output with the actual daily output. The last column is reserved for remarks. Probably others have on hand records of a similar character, showing the comparative efficiency of workmen, subjected to a more rigid system than ours. The results of such investigations would probably be interesting to the readers of MACHINERY. H. D. Y.

PIRATING.

In a recent issue of MACHINERY an editorial appeared on "Pirating Special Machine Tools" which calls to mind another form of piracy which is possibly more common. This is the taking of ideas from other concerns in designing a machine for the market. How many times do we hear the words, "Why, that new machine of the Jones Machine Co. was designed by Smith who used to be with Jones' competitors. You can see the other fellow's ear-marks on Jones' new machine." This is probably the least objectionable form, for a man who designs a machine for one firm will probably follow more or less the same lines in designing for another concern a machine of similar nature. The next step in these forms of pirating is for one designer to take his ideas deliberately from a competing concern.

Here is the story which was told me by the draftsman who did the "designing." A concern manufacturing pumps decided to bring out a new type, and gave the draftsman general instructions as to what special features the design should include, leaving the details to be worked out by him. The draftsman happened to recall having seen a pamphlet of a competing pump manufacturer showing a pump somewhat on the lines proposed. He hunted up the pamphlet, which, by the way, announced that the pump shown was a strictly new departure. The draftsman, not letting it be known that he had the circular, followed out the design to a large extent. Things progressed, and the first pump was made according to the design and about ready to be tested, when, one day, into the drafting-room walked the manager. "There's a leak in this factory somewhere," said he to the draftsman. "Here the ———, ——— & Co. have gotten out a pump exactly on the line of our new pump. Somebody in this shop must have given it away to them." He had come across the circular the draftsman had used. A. A. ANDREWS.

THE GAGING OF HEATS FOR HARDENING.

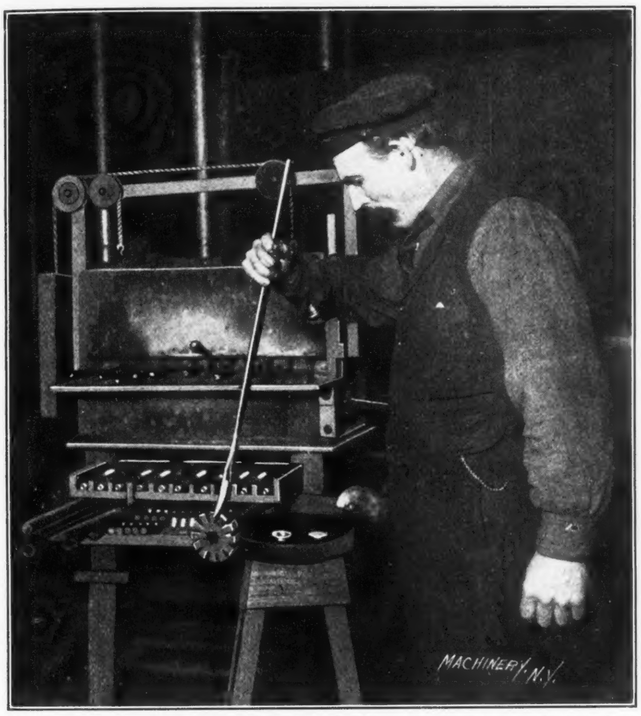
In a recent issue of a technical magazine, I read an article on a very important subject: The heat treatment of carbon steels. This is a subject that is uppermost in the minds of a great many mechanics at the present time, and each one has his own ideas as to how it should be done to get the best results. They read everything published bearing on the subject, and use their own judgment as to the best methods of obtaining the right heat for hardening.

It takes an experienced man to gage the heat for hardening with the eye, at all times, and under all conditions, without heating some tools just a little hotter than they should be to get the best results, and that means sometimes spoiling an expensive tool, or, hardening the tool in such a way that it will not stand up to the work expected of it. Again, some of the tools on test will be found soft, and that means reheating, which is unnecessary when it is done right the first time, and in the case of taps, and such tools, that cannot be ground or lapped without a lot of trouble and expense, it means sometimes a loss of that particular tool.

There are various reasons why heats are not always gaged correctly. In the first place, the man has no gage to go by, and again, the light conditions, prevailing at the time, may interfere. This can be overcome by having shades at the windows, that can be adjusted. Sometimes the eye gets "off-color" and needs rest for a few minutes. The use of the "magnetic influence" in gaging the heats for hardening is practically new; in fact, a great many experienced mechanics, versed in the handling of carbon steels, have never heard of it, but the fact remains just the same. We all know that the proper heat for hardening steel to get the best and most lasting results, is the lowest heat that the steel will harden at. How are we to find this out? By the use of the magnetic needle,

no matter what the make, or brand of steel. Following these lines, the writer has experimented for two years, and, at the present time, can harden a tool or piece of carbon steel at the first heat, without knowing the brand or temper of steel, and with such results that tools hardened by this method outlast similar tools hardened in the old way, sometimes as high as 4 to 1. In every case, the tool lasts much longer, showing very plainly that this method is the best, or at least worth testing.

The gaging of heats by the magnetic needle, is done in such a way that you can test every piece, or you can test every second, or third or fifth piece, or only the first piece, and then, noting the color very carefully, harden several pieces and make no mistake. If the color seems to be off a little, test



Testing a Milling Cutter, when Hardening, by Swinging it Back and Forth past a Magnetic Needle.

again; this can be done right along, provided the steel is of the same "carbon temper," but in all cases where the carbon temper changes, the test must be made again. Some months ago I had a pair of rolls to harden, about 27 inches long by 6½ inches diameter. After sizing them up, I made inquiries as to what they were made of; one said they were crucible machinery steel; another, that they were tool steel, and the superintendent said that he did not know—it was up to me to harden them. Well, I did harden them, and without any experimenting or second heating. I heated them in a Brown & Sharpe furnace, and tested them with the magnet and with plenty of water, and did a good job. I had experimented with the magnet before, so I knew what to do. At another time I had to harden 1,000 horseshoe magnets for telephones, one-half of which were imported steel, the other half, domestic. I hardened them without any trouble, and the telephone company was pleased with the work. I found out afterward that the company had tried to harden them and could not get a uniform hardness. In this case I tested one in about every forty.

In starting my experiments, I bought a small pocket compass with a jeweled pivot and needle stop, about 2 inch diameter, and costing a dollar and a half. I got a wooden stool to rest it on close to furnace, as shown in the illustration. The stool and compass should be set in such a position that the natural swing of the work back and forth when testing, will be in a plane parallel with the needle; in other words, the piece being hardened should be swung north and south. By passing the tool being hardened (in this case a milling cutter) forward and backward close to the compass, the magnetism of the tool will cause the needle to be deflected one way, then the other, and the tool will still continue to deflect the needle until the right degree of heat has been obtained, that is, the proper heat for dipping in the bath. In other words, the right heat is when the tool loses its magnetism. It does not follow, that if the needle remains stationary, the first time you test, that the heat is right, because, after the tool has reached a certain degree of heat the magnetism leaves the steel, so there is no influence on the needle, showing plainly that the steel is too hot. The different carbon tempers and different grades of steel, require different degrees of heat, and the magnetism leaves the steel at a certain degree of heat to correspond to the different points of carbon in the steel, and in every case this is the proper heat for dipping. After testing until the right degree of heat is obtained, I put the tool back in the furnace for about twenty seconds, just to even up the heat. I then dip the tool in a water bath to set the hardness, then from the water bath to a lard oil bath until cold. In the case of the rolls previously spoken of, I had to rig up a tackle to the roof, and in place of a rivet in the tongs, I made a hook with thread and two nuts, one hook on each side of tongs, to hook into the tackle, so as to handle the work quickly.

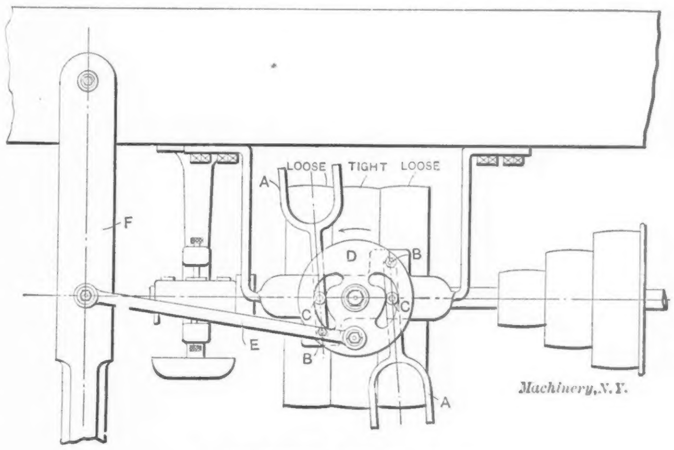
This method applies only to tools that can be heated all over, as it is obvious that heating a tool, say a tap, on the end to be hardened, would have a disturbing effect on the needle simply because only part of the tap would be hot, leaving magnetism in the shank; I am referring now to taps with long shanks. In using the magnetic needle, if it points due north and south, a large body of metal would deflect the needle, to a certain extent, from its natural position, but no matter what the position of the needle, the moment a tool is held close to it, it answers to the magnetism of the tool, and will move until the right degree of heat is reached; when this point is reached, the needle become inactive.

I make it a point to keep my furnace at 1,300 degrees F. all the time, or as near as possible to this degree of heat, and with this heat I find it is not necessary to test every piece. I have never given much thought to improving this method, but undoubtedly, there is a large field for somebody to experiment in. Geo. T. Coles.

Decatur, Ill.

A BELT SHIFTER.

The belt shifter which is shown in the cut is so simple in design and operation that little explanation is needed. The belts are guided by the forked levers *A*, which are pivoted at *B*. The rollers *C* are fixed to the forked levers, and work in the slots as shown. When the disk *D* is rotated—say in the direction of the arrow—by the levers *E* and *F*, the left roller is forced toward the center of the plate *D*, thus moving the forked lever to the right and shifting the belt on the tight pulley. The belt on the right side is not moved during this



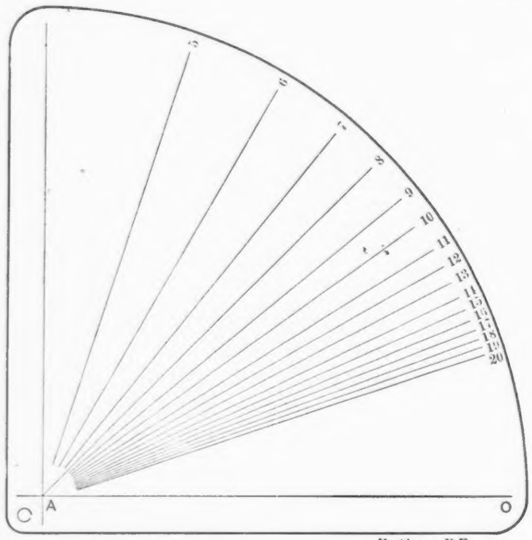
A Belt Shifter of Simple Design.

operation, as the right roller moves in a part of the slot which is concentric with the plate *D*. If the disk *D* had been rotated in a direction opposite to that indicated by the arrow, the movements would, of course, have been reversed, the right belt being shifted, and the left one remaining stationary. This shifting device has, in many cases, given better satisfaction than the friction clutch, as it does not get out of order as easily, and it is not so likely to run warm. Charles Roels.

Antwerp, Belgium.

TOOL FOR SPACING BOLT HOLES.

In drawing flanges, cylinder heads, etc., where a number of holes are shown on a given pitch circle, it is usually desirable to have them located correctly on the drawing, for the sake of appearance at least, even if not really important otherwise, and for this purpose the tool shown in the accompanying cut was designed. It is a very convenient instrument, made from transparent sheet celluloid, about 1/64 inch thick. The method of procedure when using this tool is to draw the pitch circle, and then place the instrument over it, with the point *A* on the center. One point of the dividers is placed on the line *A O*, at the point where it intersects the pitch circle, and the other point of the dividers is set at the inter-



Tool for Spacing Bolt Holes.

section of the pitch circle and the radial line marked with a number corresponding to the required number of holes in the whole pitch circle. This gives the correct spacing for the number of holes required. If reasonable care is used in the construction of this tool, it will be found to give very close results. The design, of course, can be varied to suit special requirements. The one shown in the cut was made by laying off the correct angles on the circle having 18 inches radius, and scratching the radial lines with a needle point on the celluloid, after which drawing ink was rubbed into the scratches so as to make them show plainly. F. W. C.

BALL-BEARING CONE CENTERS.

The subject of cone centers is one that has received much attention and thought from designers and mechanics for many years, and the story of the many unsuccessful attempts to design a ball bearing cone center would prove interesting reading if such an article could be written. In presenting

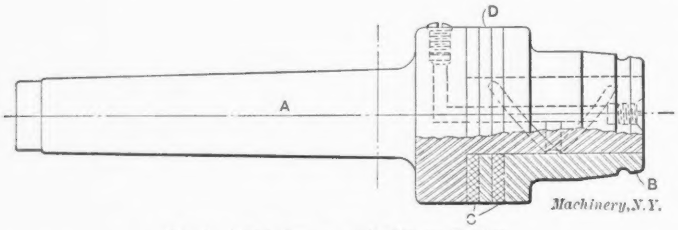


Fig. 1. Cone Center of Ordinary Design.

this article, I wish to call attention to the gradual design or evolution of a most satisfactory center of this description, where a failure was turned into a complete success.

Fig. 1 shows the ordinary and most widely used cone center, also the simplest one, and the one most easily made, consisting as it does of the center proper *A*, the cone *B*, the two fiber washers *C*, and the hardened steel washer *D*. While this center will give "good enough" service in many cases, for durability and accuracy, the design is bad. The center bearing of cone *B* wears, and the cone very soon runs out of true, and this error is produced many times in the finished work. The worst feature of this design is that there is no way to prevent the small particles of steel, dirt, etc., from getting into the wearing surfaces and causing trouble. The washers *C* also wear very fast, and although many different forms and materials have been tried, the fact remains that they soon wear out, drop off, and get lost, or are mislaid. This last fact gives us the first essential of a successful cone center.

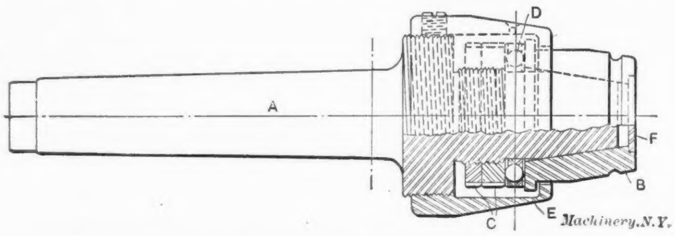


Fig. 2. Ball-bearing Cone Center which proved Unsatisfactory.

It should be self contained, and made in such a manner that the component parts are held in such a way as to prevent their being lost. The design shown in Fig. 2 was not expected to entirely overcome the wear on the cone bearing. The ball bearing *D*, was introduced and adjusting nuts *C* to provide adjustment for the cone *B* as fast as the cone bearing on spindle *A* should wear. This center also proved a failure owing to the variation in the diameter of the balls, the change in the alignment of the adjusting nuts, and the fine adjustments necessary to keep the cone true, all of which led to a combination that was too expensive to maintain, and caused the final abandonment of the design. In this design it will be noticed that the retaining guard *E*, and dirt guard *F* have been added. The final and successful center is clearly shown in Fig. 3, in which *A* is the shank having two grooves or ball races at *D* to receive 24 and 48, 1/8-inch balls, respectively. The cone *B* is hardened and ground inside and out, and has a flange a little smaller in diameter than the shoulder on *A*, allowing retaining guard *E* to slip over the cone. This guard is held in position on the shoulder of *A* by the set-screw, as shown, and prevents too much freedom of movement of the cone *B*. In order to provide for the grinding operations, and provide a dust guard, a recess is cut in the

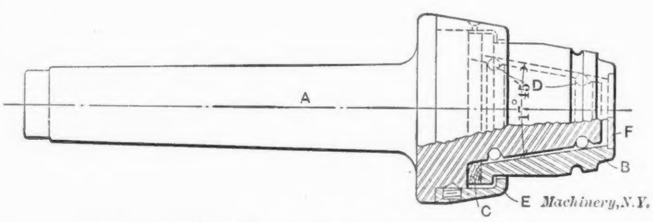


Fig. 3. Ball-bearing Cone Center of Improved Design.

small end of *B*, and, after the center is assembled and adjusted, the cone *B* is removed and a disk *F* forced into place, leaving the end flush, thus preventing any dirt or chips getting into the ball races. A felt washer *C* acts as a filter between the shank *A* and the cone *B*, and, while allowing the water to fill the cone, prevents all foreign matter getting near the balls, and at the same time allows the balls to revolve in a water bath, keeping them cool. After 500 valves had been ground, the cone and shank showed no perceptible wear, and after the first 1,000 had been turned out, the center was declared to be "just getting into good shape." One of the important points in this design is that the bearing point of the work is in direct line with the ball bearing, thus preventing the leverage which would result if the point of contact were at the extreme outside point of the cone.

There are many points to be considered in the production of this center. I have in mind a tool-maker (?) who, after the cone had been carefully ground and the center assembled for inspection, before disk *F* had been put into place, instead of removing cone *B*, carefully placed disk *F* in position and then applied pressure against the disk, cone, and balls. Naturally upon trial the center developed a bad case of "wobbles," and this tool-maker then declared that, "that cone was the worst job of grinding that he had ever seen."

Easton, Pa. F. R. PEIRCE.

SHOP RECEIPTS AND FORMULAS.

A DEPARTMENT FOR USEFUL MIXTURES.

This page is intended to be used only for the publication of such shop receipts as the contributors know from experience to be practicable. Receipts are solicited on the condition that the contributors personally know that they are reliable. The fact that a receipt is old and supposedly well-known does not bar it, provided it has not already appeared here.

398. LUBRICANT FOR ALUMINUM CUTTING.

The following mixture makes the best lubricant for turning, or any other machining operation on aluminum, that I have ever tried: Mix 1 part good lard oil with 4 parts of kerosene oil. It beats anything yet published in this department.

A. A. STEVENSON.

399. TO MAKE LIQUID GLUE.

Take one quart soft water and 2 pounds of pale glue; dissolve in a covered vessel by the heat of a water bath, cool, and add gradually 7 ounces of nitric acid (specific gravity 1.335). This glue is very strong and will not gelatinize.

C. S.

400. LUBRICANT FOR FITTING ALUMINUM THREADS.

When screwing an aluminum article on to an iron or steel part, much trouble is often experienced by the breaking and tearing of the threads of the softer metal. This can be prevented by lubricating the screw well with a mixture of oil and graphite.

SREGOR.

401. MATT DIP FOR BRASS.

To make a matt dip for brass, mix 1 part sulphuric acid in 1 to 2 parts of nitric acid and 1 part sulphate of zinc. Let the mixture stand 24 hours, and use hot. More or less nitric acid gives a fine or coarse effect, as may be preferred.

Bridgeport, Conn. J. L. LUCAS.

402. TO PREVENT SCREWS FROM GETTING RUSTY.

To prevent screws from getting rusty and sticking tight, instead of using ordinary oil only, add some graphite. After years you will be able to unscrew them with ease, and find them as bright as new, even if they were exposed to very damp air.

J. M. MENEGUS.

Los Angeles, Cal.

403. TO DISSOLVE GLASS.

A hole may be cut or etched through glass readily by using hydrofluoric acid. The acid should be applied in the same way as etching acid, using wax to surround the portion of the glass which is to be penetrated. Hydrofluoric acid is sold in wax bottles, as it cannot be kept in glass. It may be handled with a hard rubber dropper similar in construction to the ordinary glass medicine droppers.

S. W. GREEN.

404. TO ANNEAL HIGH-SPEED AND AIR-HARDENING STEELS.

To anneal "Novo" or "Blue Chip" high-speed steel or any of the air-hardening steels, pack the steel in a piece of gas pipe with powdered charcoal, and seal the ends with clay or caps screwed on. Heat to a cherry red, giving time for the contents of the pipe to reach this temperature, and then set in a dry, sheltered place to cool. The steel will be found annealed so that can be readily drilled, turned, planed or worked as required.

A. A. STEVENSON.

405. TO MAKE A WATER-TIGHT JOINT.

Take ordinary white lead, and mix enough powdered red lead with it to make a paste the consistency of putty. Spread this mixture on the joint, and when it hardens, the joint will be perfectly water-tight. We used this mixture on flanges on a standpipe, after we had tried all kinds of rubber gaskets without success. The mixture hardened and made a tight joint, never leaking afterward.

J. D. PAGE.

Youngstown, Ohio.

406. TO TEST WHITE LEAD.

This simple test to determine the purity of white lead may be found useful where much painting is being done. It is as follows: Select a piece of charcoal of firm structure, and hollow out a cavity in one side about ½ inch in diameter and of the same depth. Put a sample of white lead in the hollow about the size of a pea, and subject it for a few moments to a blow-pipe flame. If the sample is pure, it will quickly reduce to metallic lead. Adulterated white lead will generally contain a residue that cannot be reduced.

M. E. CANEK.

407. ALUMINUM SOLDER.

The following is a receipt for aluminum solder which we are using with success in the Elwell-Parker Electric Co.'s shop, Cleveland, Ohio. It is the result of experiments made by several of our foremen: Pig tin, 12 ounces; sheet zinc, 3 ounces; mercury, 1 ounce. Melt the zinc first and then add the tin. When the tin is melted remove from the fire and add the mercury while still in the molten state. Be careful to stir the mixture thoroughly before pouring into the mold. Use stearic acid for a flux.

L. MILLER.

Cleveland, Ohio.

408. PARTIAL CASE-HARDENING.

The entire surface of the work, or that part which is to be hardened, should be coated with a moderately heavy coat of Japan enamel, and then a medium heavy coat of copper should be applied to the remaining portion of the work. In applying the copper, care should be taken not to disturb the Japan. After the copper is applied, the piece is ready to be carbonized. It should be packed, and heated to a bright red, and held at this heat long enough for the requirements of the work. Then the box or case, containing the pieces to be case-hardened, are taken out of the fire and the work is permitted to cool in the box. When cool, the work is taken out and reheated in the open fire, and dipped in oil or water. The copper prevents the absorption of the carbon, while the Japan enamel burns off and allows the carbon to take effect.

E. S. WHEELER.

409. HARDENING CAST IRON.

The following process can be used for hardening cast iron whether rough or after machining. The casting is first heated to a cherry-red heat; it is then dipped in a bath which consists of a practically anhydrous acid of high heat-conducting power, preferably sulphuric acid of a specific gravity of from 1.8 to 1.9, to which is added a suitable quantity of one or more of the heavy metals or their compounds—such, for example, as arsenic or the like. The preferable ingredients of the bath are sulphuric acid of a specific gravity of approximately 1.84 and red arsenic in the proportions of ¾ pound of red arsenic crystals to 1 gallon of sulphuric acid. The castings may be either suddenly dipped in the aforementioned mixture, and then taken out and cooled in water, or they may be left in the bath until cool. In preparing the bath, when sulphuric acid and red arsenic are used, better results are obtained when the crystals are added to the sulphuric acid and the bath is allowed to stand for about a week before using.

O. G.

410. A TEMPERING SOLUTION.

A tempering solution used for high heats may be composed of two parts Chili saltpeter and one part nitrate of soda. This tempering solution is used only at high temperatures, as it becomes solid at about 500 degrees F. It is used in place of tempering oils, as they often thicken after short use, and will flash or ignite at about 600 degrees F., and often at a lower temperature. It should be used in connection with a tempering furnace, the heat being gaged by a thermometer. The thermometer should be removed when the day's work is over. At night, two iron plugs, with a fairly liberal taper per foot, and long enough to reach from the inside bottom of the tank containing the bath, to about four inches above the top of the solution, should be placed vertically with the small end of the taper down, and some little distance apart. These should be permitted to stay in the solution when it solidifies. On the following morning, these iron plugs should be unscrewed and removed. The holes left in the solidified solution by these plugs afford an escape for gases that form in reheating the bath.

E. S. WHEELER.

HOW AND WHY.

A DEPARTMENT INTENDED TO CONTAIN CORRECT ANSWERS TO PRACTICAL QUESTIONS OF GENERAL INTEREST.

Give all details and name and address. The latter are for our own convenience and will not be published.

WIDTHS OF TOOLS FOR CUTTING SQUARE THREADS.

C. H. H.—Please give, in your "How and Why" columns, the dimensions for tools used for cutting square threads. As is well known, in order to procure clearance between threads in the screw and the nut, when provided with square threads, the threads in the screw and the nut must be cut somewhat different from what would be the actual theoretical standard width for square threads. What I wish to know is the width of the point of the tool for cutting screws and nuts having square thread.

A.—When cutting square threads it is customary to make the screws exactly according to the theoretical standard of the square thread. The width of the point of the tool for cutting *screws* with square threads is therefore exactly one-half of the pitch, but the width of the point of the tool for cutting taps, which afterwards are used for tapping nuts, is slightly less than one-half the pitch, so that the groove in the tap becomes narrower, and the land or cutting point wider than the theoretical square thread, thereby cutting a groove in the nut which will be slightly wider than the thread in the screw, so as to provide for clearance. An inside threading tool for threading nuts evidently must be of the same width as the land on the tap would be, or in other words, slightly wider than one-half the pitch. This provides, then, the required clearance. The accompanying table gives the width

TABLE OF WIDTHS OF TOOLS FOR CUTTING SQUARE THREADS.

Number of Threads per inch.	Width of Point of Tool for Taps.	Width of Point of Tool for Screws.	For Inside Thread Tools for Nuts.
1	0.4965	0.5000	0.5035
1 1/3	0.3715	0.3750	0.3785
1½	0.3303	0.3333	0.3363
1¾	0.2827	0.2857	0.2887
2	0.2475	0.2500	0.2525
2½	0.1975	0.2000	0.2025
3	0.1641	0.1666	0.1691
3½	0.1408	0.1428	0.1448
4	0.1235	0.1250	0.1265
4½	0.1096	0.1111	0.1126
5	0.0985	0.1000	0.1015
5½	0.0894	0.0909	0.0924
6	0.0818	0.0833	0.0848
7	0.0699	0.0714	0.0729
8	0.0615	0.0625	0.0635
9	0.0545	0.0555	0.0565
10	0.0490	0.0500	0.0510
11	0.0444	0.0454	0.0464
12	0.0407	0.0417	0.0427
13	0.0375	0.0385	0.0395
14	0.0352	0.0357	0.0362
15	0.0328	0.0333	0.0338
16	0.0307	0.0312	0.0317
18	0.0272	0.0277	0.0282
20	0.0245	0.0250	0.0255
22	0.0222	0.0227	0.0232
24	0.0203	0.0208	0.0213

of the point of the tool for all ordinary pitches from one to twenty-four threads per inch. The second column gives the width of the point for cutting taps to be used for producing square thread nuts. The third column gives the width of the point of the tool for cutting screws which, as we have said, equals one-half the pitch, and the fourth column gives the width of the point for inside threading tools for nuts. While the table has been carried to as fine pitches as those having twenty-four threads per inch, square threaded screws having so fine a pitch are very seldom used. Some manufacturers of square threading tools, however, make square threading tools for pitches as fine as these, and for this reason they have been included.

TRUCK EQUALIZER.

H. E. R. How should fiber stress and thickness be determined for a truck equalizer such as shown in Fig. 1? The total load on the truck is 43,000 pounds, supported by two springs, each spring hung between two equalizers.

A.—This equalizer is a beam supported at the ends and loaded symmetrically at two points between the supports, and should be so considered in figuring the fiber stress for a given load, except as the calculations are modified by the curved shape. The maximum bending moment and fiber stress will occur at the points where the springs are attached, and at all sections between these two points.

Fig. 2 shows the method of finding the bending moment at section $x\,y$ through the point of spring suspension, or at any other point $x_1\,y_1$ between the spring and the support. The sections must be taken at right angles to the neutral axis,

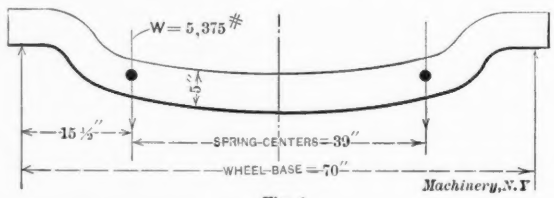


Fig. 1.

and the distance l is measured from the neutral point of the section perpendicularly to the line of reaction. The bending moment at all points between B and the corresponding point on the opposite side of the center line is the same as at B

Between B and the point of support when the sections are at a different angle from the reaction, as in Fig. 2, there is a direct tensile stress to be added to the maximum tensile stress due to bending. The greater the angle, the greater this stress. It is found as given by the formulas in Fig. 2. Between point B and the corresponding one the other side of the center line, the angularity of the section makes no difference, and does not enter into the calculation at all. In this calculation we will consider that the hole for the spring sup-

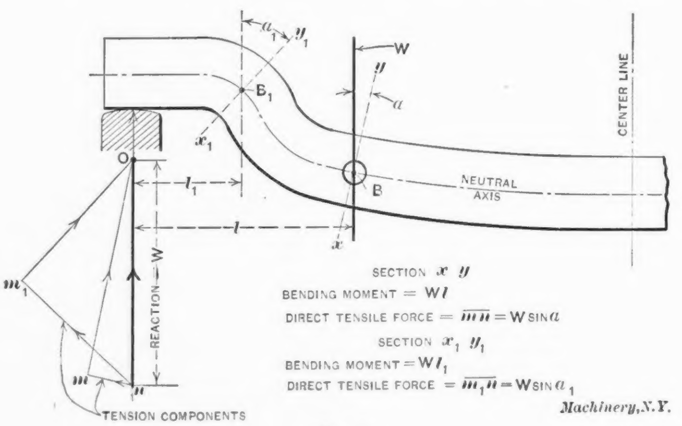


Fig. 2.

porting pin is located on the neutral axis. The section will be the strongest if this is the case, and there seems to be no good reason why it should not be so located.

In the formulas and calculations these reference letters will be used, in addition to those given in Figs. 2, 3 and 4.

A = area of section.
W = load = reaction.
M = bending moment.
Z = section modulus.
s_b = fiber stress due to bending.
s_t = stress due to direct tension.
s = total tensile stress.

The maximum tensile stress at any section between B and the point of support is found by the following formulas:

$$s_b = \frac{M}{Z} \qquad (1)$$

$$s_t = \frac{W \sin \alpha}{A} \qquad (2)$$

$$s = s_b + s_t \qquad (3)$$

To find M, see Fig. 2; to find Z, see Figs. 3 and 4.

The section at $x\,y$, which is the weakest, sustains the maximum fiber stress. Assuming that $b = 1\frac{1}{2}$ inch and $d = 1\ 1/8$ inch (Fig. 4), the maximum stress is found by the following calculations:

$M = 5{,}375 \times 15.5 = 83{,}312.5$ inch-pounds See Fig. 2.

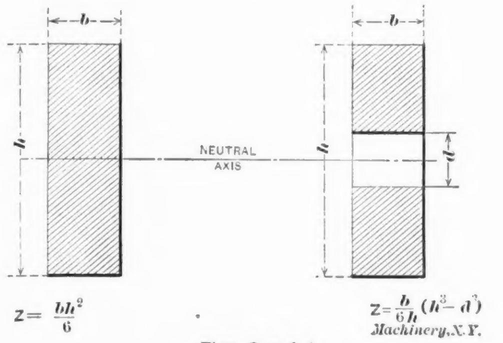
$$Z = \frac{1.5}{6 \times 5}(5^3 - 1.125^3) = \frac{123.577}{20} = 6.1788 \quad \text{See Fig. 4.}$$

$$s_b = \frac{83,312.5}{6.1788} = 13,500 \text{ pounds per square inch—about. See (1)}$$

The section seems to have an inclination of about 12 degrees, of which the sine is about 0.208.

$$s_t = \frac{5,375 \times 0.208}{3.875 \times 1.5} = 192 \text{ pounds per square inch—about. See (2)}$$

$$s = 13,500 + 192 = 13,692 \text{ pounds per square inch.} \quad (4)$$



Figs. 3 and 4.

If we take any other section to the left of B, such as $x_1 y_1$, we will find the maximum fiber stress considerably less than at $x y$. This section has an inclination of about 43 degrees.

$$M = 5,375 \times 7.5 = 40,312.5 \text{ inch-pounds.}$$

$$Z = \frac{1.5 \times 5^2}{6} = \frac{25}{4} = 6.25. \quad \text{See Fig 3.}$$

$$s_b = \frac{40,312.5}{6.25} = 6,450 \text{ pounds per square inch.}$$

$$s_t = \frac{5,375 \times 0.682}{5 \times 1.5} = 490 \text{ pounds per square inch.}$$

$$s = 6,450 + 490 = 6,940 \text{ pounds per square inch.} \quad (5)$$

In these calculations, we have assumed a thickness b of 1½ inches. This gives, see (4), a maximum fiber stress of 13,692 pounds. This is a reasonable value for wrought iron. The thickness is greater than usual, and it would be better, perhaps, to make the bar somewhat wider and so reduce its thickness.

* * *

CALCULATING THE SIDE OF AN INSCRIBED POLYGON.

FRED WALSLEBEN.

In the February issue of MACHINERY a method is suggested for determining the sides of regular inscribed polygons when the number of sides increases in geometrical proportion in the ratio 2. The method suggested must seem rather vague to those not acquainted with its proof. It is only applicable to polygons whose radius is unity, and its application involves a confusing alternation of minus and plus signs. A more satisfactory way is as follows:

Given the side a and the radius R of a regular inscribed polygon, to find the side D of a regular inscribed polygon of double the number of sides and the same radius:

$$D = \sqrt{R\,(2\,R - \sqrt{4\,R^2 - a^2})}$$

This formula is general. Its derivation and proof can be found in any treatise on plane geometry.

* * *

A report from Consul-General Richard Guenther, of Frankfort, Germany, states that in 1907 the production of denatured alcohol in that country was 27,720,000 gallons, an increase of about 2,900,000 gallons over the previous year. The price for alcohol was high, having been considerably advanced at different times, but in the report, the actual price per gallon is not stated. It is stated that the alcohol production in Germany is controlled by a trust or combination, which fixes both the amount of production and the price. German alcohol is made principally from potatoes.

SOME EXAMPLES OF ELECTRIC WELDING.

Although the electric welding process passed out of the experimental into the practical stage some years ago, to most mechanics electric welding is still a rather vague subject. Electric welding, however, plays an important part nowadays in the manufacture of a great many articles, and several companies have been formed which devote their entire attention to the manufacture of articles in which electric welding is an integral part of the manufacturing process. Without the process of electric welding, many of these products would have to be manufactured in an entirely different way, and in many cases at a greatly increased cost.

It may be well to state at the outset that there are at least four distinct processes of electric welding in use at the present time. These processes are commonly named the Zerener, the La Grange-Hoho, the Benardos, and the Thomson processes. In the process first mentioned above, the Zerener process, perhaps more commonly known as the electric blow-pipe method, an electric arc is drawn between two carbon electrodes. This arc is then caused to impinge upon the metal surfaces to be welded, by means of an electro-magnet.

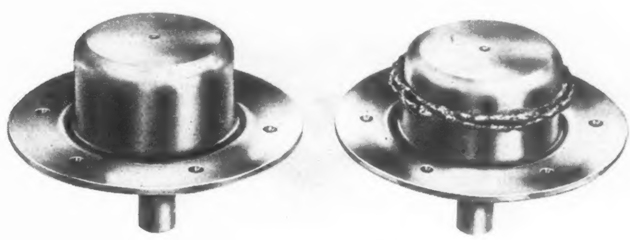


Fig. 1. Automobile Hub Completed by Electric Welding.

The second process mentioned, the La Grange-Hoho, commonly known as the "water-pail forge," is distinctly different from all the other processes in principle, as well as in its practical application. A wooden tank is filled with a suitable fluid, and in this the positive electrode of the electric circuit is placed. The negative electrode is connected to the metal to be forged or welded, which is then immersed in the fluid in the tank. The metal is permitted to remain in the fluid until it has reached a welding temperature. The object to be welded is then removed, and the actual forging or welding process is carried out in the usual manner under a hammer. Strictly speaking, this is not an electric welding process, but merely an electric heating process to bring the metal to a welding heat.

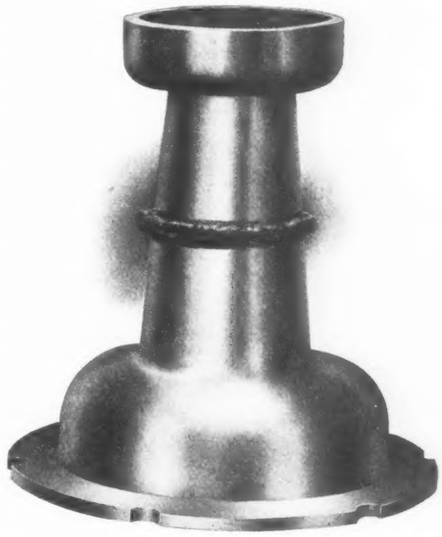


Fig. 2. Electric Weld on Automobile Pinion Casing.

The characteristic principle of the Benardos process is that an electric arc is drawn directly between the metal to be welded, which itself forms one electrode for the electric circuit, and the carbon electrode, which forms the other terminal for the circuit. In this process the pieces of metal to be welded are melted on their faces, together with a small rod of iron which acts as a kind of solder, and flows in between the two surfaces to be joined together by the welding process.

Finally, in the fourth, or the Thomson process, often known as the incandescent process, the metals to be welded are brought into intimate contact, being usually held closely together by metal clamps actuated by springs so as to permit

a permanent pressure on the parts even when the metal at the welding surfaces commences to melt. By this contact, the parts to be welded complete an electric circuit, and the resistance at the points of contact between the metals produces a welding temperature in a very few seconds, at the same time as the two metals are, by the spring-actuated clamps, forced together automatically, and welded. A distinct feature of this electric welding process is that the interior is raised to a welding temperature before the surface reaches that heat. When heated in the forge for welding, the opposite conditions take place. In the process of electric welding, if the exterior surfaces weld, the operator is sure that the interior is also welded, since it must, by necessity, be of a somewhat higher heat. With ordinary forge welding the surfaces may present a perfect weld and still cover an imperfect joint inside. The accompanying photographs show a number of applications of electric welding, as carried out in the shops of the Standard Welding Co., Cleveland, Ohio, by the use of the Thomson process, which will illustrate its possibilities.

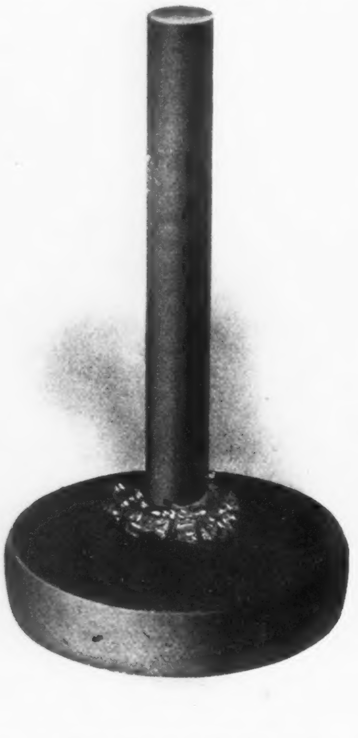


Fig. 3. Stem of Carbon Steel Welded to a Soft Steel Disk.

A few years ago it was thought that electric welding would be practical only for very small objects, on account of the high amperage required, but since that time the process has been developed so that it is now possible to electrically weld parts of considerable size. The process is particularly suited for the manufacture of automobile and bicycle parts, carriage hardware, and mechanics' tools of various descriptions. While the process is employed to a considerable extent among manufacturers, it is probable that in the shops of the company mentioned above there is a greater variety of work welded by the electric process than in any other.

When, as mentioned above, the two parts to be welded have been placed against each other, in the electric circuit, which heats the metal at the juncture to a molten state, the separate parts will be united into one piece in such a manner that the joint is practically imperceptible, but at first a burr or upset is produced around the welded surface, composed of the expelled oxidized and otherwise inferior metal. This oxidation, examples of which are shown in all of the accompanying cuts, is, of course, removed, and then a perfect joint is the result. In the cut, Fig. 1, an automobile hub is shown, on which an electric welding process has been performed. The dome or cover and the spindle of the hub are drop forged as an integral part, the flange being produced under a power press. The parts are then roughly machined, so as to be fairly uniform in the dimensions where the joint is to take place, and are then subjected to the electric welding process. At the right, in the cut, the hub is shown with the burr or upset resulting from the welding process still left in place, while at the left is shown the finished hub after this burr has been removed. The turning and grinding operations complete the work, producing practically a solid hub.

The cut, Fig. 2, illustrates an automobile pinion casing. The parts for making up this casing are of stamped steel. The burr incidental to the welding process is shown, in order to indicate where the joint is located. While the welding process is being carried out, the parts are held in alignment so that after being roughed and finished, and after having been cupped at the ends, the ball races will be in correct alignment.

In the cut, Fig. 3, is illustrated a soft steel disk, welded to a stem or spindle, containing from 0.12 to 0.60 per cent carbon. The detail shown is used largely in the manufacture of cream separator bowls, but, of course, similar applications are found in a great many other machines. It is possible to join soft steel disks to stems or spindles of even higher carbon content than that mentioned.

In Fig. 4 is shown a double lever or arm welded to the steering knuckle on an automobile. This illustration presents a case where it would not be possible, without greatly increased expense, to produce the part without electric welding.

The illustrations shown are, of course, only general examples of what can be accomplished by means of the electric welding process, but they are suggestive to the mechanical mind which may be unfamiliar with the wide field of application for electric welding, indicating as well, that the future of electric welding is one of great possibilities. For a more complete description of the shops, methods and products of the Standard Welding Co., see MACHINERY, April, 1903.

One very important question in regard to electric welding, and for that matter any other process for joining metallic parts, is whether the joint is sound. Experiments and tests, as well as use of electrically welded joints, have unquestionably demonstrated its reliability. In the case of electric welding, the great variety of parts so joined has shown, beyond doubt, that the joint is practically as sound as the solid sections in the parts so joined. Very commonly the parts which are welded by the electric process are subjected to abuse and rough handling, or to heavy stresses. Especially is this so in automobile work. The results obtained have been so satisfactory as to place the art among the most useful of the applications of electricity.

In this connection, it may be well to mention that the Thomson process, while originally an American invention, has also received considerable attention in England. A writer in the *London Times* some time ago, called attention to the fact that the system has caused a complete revolution in existing methods of manufacture in many industries, and that electric welding had created some entirely new manufactures. As to the reliability of these joints, this writer also mentioned that tests had been carried on regarding the comparative strength of electric and ordinary forged welds, and that these tests show that while the ordinary forge weld of iron bars shows an average strength of 89.3 per cent, as compared with the strength of the solid, electrically welded joints show a strength of 91.9 per cent.

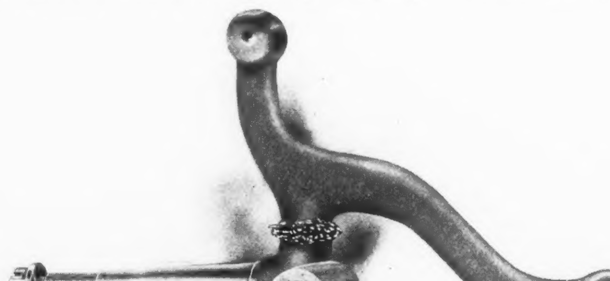


Fig. 4. Welding Operation on Automobile Steering Knuckle and Lever.

In giving a summary of the advantages which can, with propriety, be claimed for the electric welding process, the following may be stated as being the most important: Finished or nearly finished work may be welded and repaired without damage; the welding operation can be closely watched as it proceeds, and faulty welds prevented; the process is carried out with great rapidity, occupying only a few seconds, and in small work it is performed almost instantaneously; and, finally, impurities are expelled from the joint, and a perfectly homogeneous weld is obtained. The cost for the generation of heat, generally speaking, is probably the same for forge and electric welding, but with the electric process the cost of labor is greatly reduced.

THE SETTING UP AND OPERATION OF THE POTTER & JOHNSTON AUTOMATIC CHUCKING MACHINE.—1.

The invasion by the automatic turret machine of the field so long held by the lathe, in its work of machining castings, has been one of the important developments of the past decade in the machine tool business. Beginning with the original automatic screw machine, which first came into use a quarter of a century ago, the automatically operated turret machine has steadily found wider and wider fields of usefulness, being applied first to small turned parts made from bar stock, later to small castings, and more recently to the machining of castings and forgings of considerable size.

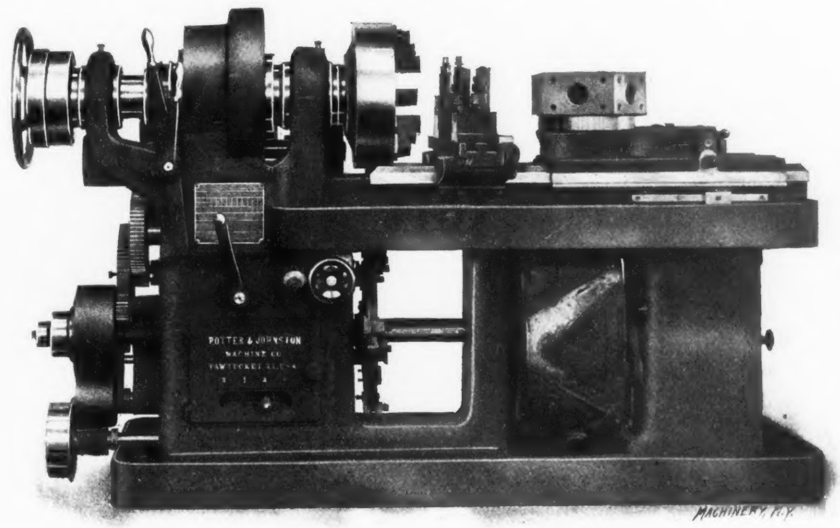


Fig. 1. Potter & Johnston Automatic Chucking and Turning Machine, with Two-speed Geared Spindle Drive.

The automatic chucking machine shown in Fig. 1, built by Potter & Johnston, Pawtucket, R. I., is the logical result of this extension of the automatic screw machine idea to the handling of large work. There are so many of them in use, that it was believed that a description of the operation of this machine, particularly as relates to setting it up for simple work, would be valuable and interesting to our readers. This article was prepared with this in view, the information and illustrative matter it contains being gathered during a special visit to the shops of the builders, who freely provided every facility that could be asked for.

Description of the Machine.

A clear understanding of the action of the machine is essential for the operator, if he expects to set it up and work it intelligently. We will describe its construction as simply and in as few words as possible.

In Fig. 1 is shown a machine of the type from which the observations were taken. Various styles of machines are made by the builders, there being two sizes and several arrangements of the driving mechanism. Some of the machines have spindles driven directly from pulleys on the spindle. Some have one spindle speed only; some have two speeds of fixed ratio for any given piece of work; while others (as in this case, which is the form most suited for heavy chucking work in iron or steel) have two speeds available for the same piece of work, which speeds may be selected without reference to each other, from a wide range.

The principle of operation of the machine is simple. Mechanism has to be provided to stop, start and change the spindle feed; to operate the cross slide; and to feed the turret slide forward, return it quickly, rotate the turret to a new position, and feed it forward quickly for taking a new cut. The cross slide and turret slide movements are effected by cams mounted on the large drum seen beneath the turret in Fig. 1, while the various feed and speed changes are effected by dogs and pins carried on a disk keyed to the same shaft on which the cam drum is mounted. This shaft, with the cam drum and the governing disk, makes one revolution for each piece of work completed.

The periphery of the drum carries the cams for operating the turret slide, which is moved positively in both directions, without the use of springs. The cam roll is carried by an intermediate slide, lying in a groove in the upper surface of the bed. This slide has rack teeth cut on it, engaging a pinion on the squared shaft, seen projecting from the side of the turret slide. By turning this shaft with a crank, the position of the turret slide with relation to the cam may be altered, so that it may be adjusted for long or short work and long or short tools, as may be required.

The cross-slide cams, and the means for transmitting the movement obtained from them to the cross slide, are best seen in Figs. 3 and 5. These cams are mounted on the rear face of drum *W*, and act on a roll, carried at the front of yoke *A*, which extends diagonally upward toward the rear of the machine. The rear end of this yoke has rack teeth formed on it, meshing with teeth of a segmental pinion, which is fast to a stout rock shaft *B*, extending lengthwise of the machine at the rear. At the head-stock end, this rock shaft carries another segmental pinion, meshing with rack teeth formed on the cross slide. The movement imparted to the yoke by the cams, is thus transmitted through the pinions and the rock shaft to the cross slide.

The cam drum is driven by a pinion meshing with a gear (seen in Fig. 1) which is fast to its front periphery. This pinion is driven through a train of gearing from pulley *L* (see Fig. 6), which is belted to the spindle. The feeds are thus always dependent on the spindle speeds, as should always be the case in any machine of the lathe type. By means of epicyclic gearing and suitable clutches, the motion thus derived from the spindle may be made either very rapid, for returning the turret to be indexed and then advancing to the cutting position again, or very slow for the forward feed. These changes from slow to rapid movement or *vice versa* are effected by mechanism operated from a cam on a shaft whose outer end terminates in a star-wheel, shown just at the right of the small hand-wheel beneath the main head-stock bearing in Fig. 1. Whenever the motion is to be changed, this star-wheel is operated by pins carried by the governing disk, seen best in Fig. 6. The first pin *M* that strikes it advances it one-sixth of a rotation, changing the feed from fast to slow. The next pin that strikes it will change it another sixth of a rotation, from slow to fast feeding—and so on. Hand-wheel *E* is geared with the cam-shaft on which the star-wheel is mounted, so that the feeds may be changed manually from slow to fast, or *vice versa*.

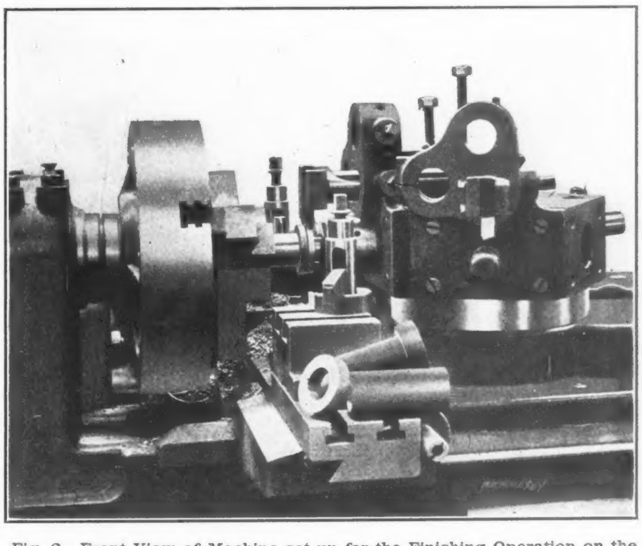


Fig. 2. Front View of Machine set up for the Finishing Operation on the Recessed Bushing and Collar shown in the Foreground and in Fig. 4.

A unique constructional feature of disk *D* is best seen in Fig. 6. The slot in which pins *M* are located is a continuous one,

extending clear around the disk, so that the rim is entirely separate from the inner portion, which is supported by the arms. The two parts of the disk are always held together, however, by the various pins carried in the slot, which are never all unclamped simultaneously. This makes the two parts practically solid, without disturbing the continuity of the slot. Besides these feed changing pins, there is also carried in this slot, a dog which operates a lever by which the feed movement is stopped, when the work has been completed.

Four rates of feed are provided for by quick change gearing of the sliding gear type, operated by handle *K* shown projecting through the door in the cabinet leg beneath the head-stock. When this handle is set in the central position, the feed is disengaged. The ability to change the feed quickly tends toward running the machine at its highest efficiency. The operator is more likely to speed the machine up, if he sees that the tools are all working too easily, than he would be

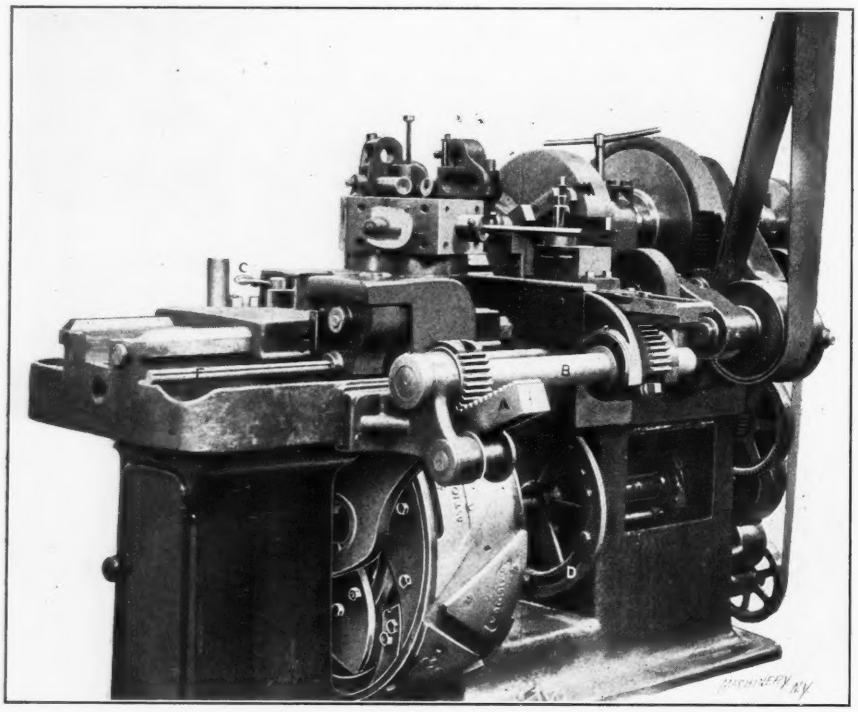


Fig. 3. Rear View of Machine set up for Work as in Fig. 2; shows the Cross-slide Mechanism, Driving Gearing, etc.

if he had to stop the machine to alter the setting of change gears of the ordinary type.

On the periphery of the governing disk are also clamped dogs or cams *N*, which operate a horizontal swinging lever *P*, connected by a link with vertical lever *J*, which controls the two spindle speeds with which the machine is provided, either one of which may thus be thrown into action at any time. The spindle driving connections are best seen in Fig. 3. As may be seen, a single speed pulley is used. The shaft on which it is mounted is connected to two sets of change gearing, enclosed in suitable guards, one on each side of the driving pulley, and each connected with its own loose driving gear on the spindle. Either of these driving gears may be connected with the spindle by clutch lever *J*, operated by the dogs *N* on the disk *D*. These driving gears are connected with the driving pulley in different ratios, and with the change gears used, ten different speeds may be obtained from each, 20 speeds being available in all, of which the two most suitable are available for any given piece. Lever *H* connects or disconnects the driving pulley with the shaft on which it is mounted, thus stopping and starting the machine.

Vertical lever *H* in the cabinet base, stops and starts the automatic feed. The shaft with the squared end, projecting from the base just at the left of hand-wheel *E*, is used with the crank to operate the drums by hand.

The rotation of the turret, which takes place at the rear of its travel of course, is effected by power. In Fig. 3 will be seen a shaft *F* extending from the head-stock through the gear casing at the rear of the turret slide. This shaft is driven from the constant speed drive pulley of the machine, and operates the turret revolving mechanism at constant speed. A dog shown in Fig. 1 at the side of the bed, is set to trip the turret revolving mechanism at the proper point in the travel to avoid interference between the tools and the work. The turret is provided with an automatic clamping device. The mechanism first withdraws the locking pin and unclamps the turret, revolves it, then throws in the locking pin and clamps the turret again. The horizontal lever at the right of the turret in Fig. 1 may be used to release the locking pin for turning the turret by hand, the clamping mechanism having been released by lever *C*, Fig. 3.

The Work and the Operations to be Performed.

The piece we have selected for illustrating the setting up and operation of the machine is shown in Fig. 4. It is a very simple piece, and will thus best serve for illustrating the principles involved. Although it is simple, it is of special interest in one or two particulars. For instance, the operation we are to perform is a second operation. In the first operation, the hole was drilled, bored and reamed, the small end of the bushing was faced, and the outside diameter finished. The enlarged diameter at the end was used for holding the work in the chuck, so, of course, it was left rough. This brings the part to the condition shown at the right in Fig. 4, where it is ready for our second operation. In this second operation we have to cut off the enlarged end, whose original purpose was that of furnishing a chucking piece to hold the work by. In order, however, not to waste any stock, this piece which we cut off is made to serve as a collar on another part of the machine for which the bushing is intended. For this purpose, we turn its outside diameter, and face the outside end of it before cutting it off. Besides this, we have to recess the bushing, as shown, and face its outer end.

In order to have the second operation dead true with the first one, we place a set of soft false jaws in the chuck (see Figs. 2 and 3) and clamp them down on a short piece of stock, slightly smaller in diameter than the diameter to be held. Then the jaws are carefully bored out to exactly the diameter of the work to be held. We can now be sure that the work will be held truly, within reasonable limits, provided the chuck is always tightened up in the same way as when it was tightened for boring.

The first thing to do is to decide on the order of operations. These are performed in the following order: On the first turret face we will turn the outside diameter of the collar, and

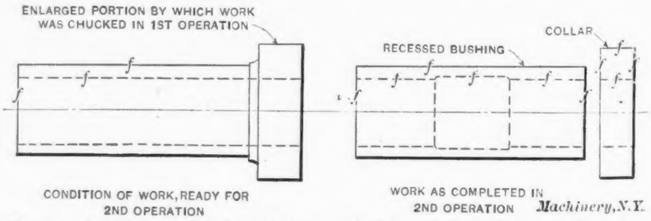


Fig. 4. The Work to be Operated on; this Second Operation recesses the Bushing, and finishes the Chucking Portion for Use on the Collar.

face the outer end. On the second turret face we will finish turn the outside diameter of the collar, and finish the outer face. The third face of the turret will not be used, this portion of the cycle being taken up in cutting off the collar with the cut-off tool on the rear cross slide. For the fourth operation we will recess the bushing, as shown in Fig. 4, and for the fifth operation we will face the end of the bushing, to remove the rough surface left by the cutting-off tool.

The tools used are shown in place in Figs. 2 and 3. For the first operation, standard turning tools are used, consisting of brackets bolted to the face of the turrets, with upward projections, provided with three holes each for carrying turn-

ing tool holders. As will be shown later, this arrangement provides for turning a number of diameters at different lengths simultaneously; but for our purpose a single turning tool for each holder will be used, located, as shown, in the lowest of the possible positions. A special device is used for recessing, as will be described later, while the facing of the end of the bushing is effected by tools so simple as to be self explanatory.

Setting the Tools.

We have first to determine the change gears to be used to get suitable spindle speeds to agree with the diameter of

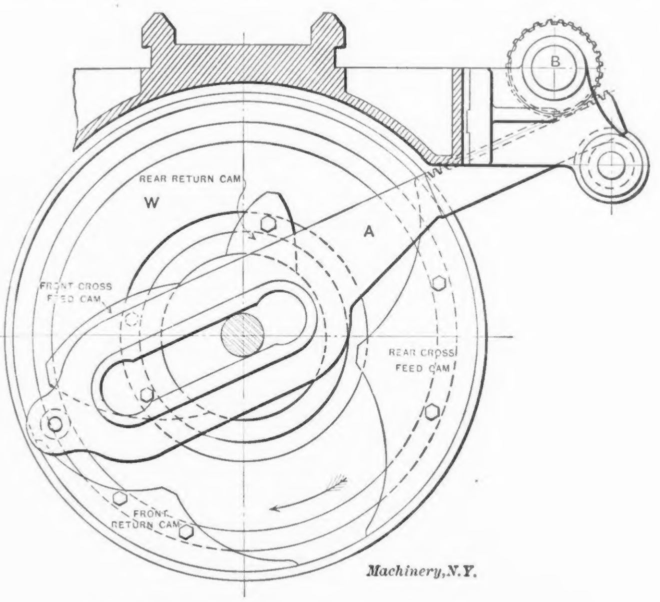


Fig. 5. Diagram of Cross-slide Cams and Mechanism.

the work. Referring to the speed and feed plate on the head-stock of the machine (see Fig. 7) we are permitted to use one speed from the list given for the fast train and one from the list for the slow train, so long as the same gears are not used in each case. The diameter of the collar for our piece of work in Fig. 4 is 2½ inches, while the diameter of the body is 2 inches. We should use a surface speed of about 40 feet per minute. A little calculation shows that the 66 revolutions per minute given by the fast train, gives 43 feet

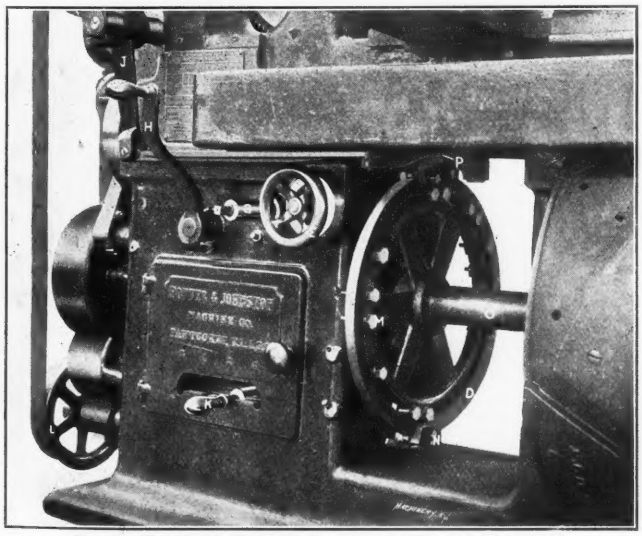


Fig. 6. The Controlling Mechanism for Feeds and Speeds.

per minute on 2½ inches diameter; and the 78 revolutions per minute obtained from the slow train of gearing, gives about 41 feet per minute on 2 inches diameter. The spindle gearing indicated for these speeds is therefore placed in position on the proper studs at the back of the machine.

Next, we have to determine on which faces of the turret to place the different tools. Each turret face is numbered to agree with the corresponding feed cam on the drum. The brass plate at the head-stock end of the machine gives the various feeds obtainable per revolution of the spindle. As will be seen, the different cams give different feeds. Cam No. 1 has a coarse feed suitable for roughing; cam No. 2 a finer feed, adapted to finishing cuts; and so on. Since our first operation consists in rough turning, it seems reasonable to give this operation to cam No. 1. Cam No. 2 will then have a finer feed for the finish turning; No. 3 is devoted to cutting off the collar; No. 4, which is ordinarily used for reaming, would, in our case, be devoted to recessing. Since this recess is for clearance only, and may be done with a coarse feed, this cam is entirely suitable.

The final operation, which is a facing one, could be done on any cam, so No. 5 will do. It will be understood, of course, that for facing operations, the feeds given do not apply. As the roll is going over the point of the feed cam at the extreme of the movement, the feed of the turret slide is gradually slowed down to zero. Since the facing takes place in the last eighth or sixteenth-inch of this movement, it is done at a feed which is gradually tapered off to zero. This is, of course, just as it should be, and we need pay no attention to tabulated feeds in facing operations.

The next adjustment to make on the machine, is that of setting the turret slide in proper position. In making this setting, the turret is set in relation to the work so that the tools will require but a small amount of over-hang, the cam-shaft having been revolved by hand until the cam-roll is on the extreme top of the forward feeding cam, so that the turret slide is at the extreme of its forward motion. When

$8\frac{1}{2} \times 16.$ NO.11 AUTOMATIC $3\frac{9}{16}$ SPIN

SPINDLE REVOLUTIONS PER MINUTE

SPINDLE SPEED FAST TRAIN OF GEARS	150	120	98	80	66	55	45	37	30	24
UPPER CHANGE GEAR	18	21	24	27	30	33	36	39	42	45
LOWER CHANGE GEAR	45	42	39	36	33	30	27	24	21	18
SPINDLE SPEED SLOW TRAIN OF GEARS	78	62	51	42	34	28	23	19	16	12

TURRET FEEDS PER REVOLUTION OF SPINDLE

CAM NUMBER		1	2	3	4	5
HANDLE POSITION	1	.006	.003	.004	.009	.005
	2	.013	.007	.008	.018	.010
	3	.024	.012	.015	.034	.018
	4	.047	.025	.029	.068	.036

DRIVING PULLEY 330 REVOLUTIONS PER MINUTE
FOR SPECIAL CAMS SEE DIAGRAMS IN CATALOGUE
POTTER & JOHNSTON MACHINE CO.,
PAWTUCKET R.I. U.S.A.

Machinery,N.Y.

Fig. 7. Plate on the Head-stock, giving the Feeds and Speeds for the Machine.

this adjustment has been made by the means provided, set the turret index tripping dog so as to revolve the turret at the proper point.

We have, then, a standard turning tool holder on face No. 1. In the lowest hole of this is placed a turning tool stem with a cutter in place. With cam No. 1 in action, we revolve the cam by hand until the roll is on the point of the cam and the turret at the forward extreme of its motion. At this point we set the turning tool stem, so that when the cutter is in place it will have completely passed over the surface to be turned. Clamping the stem in this position we turn the feed cam backwards, returning the turret slide toward the rear again, and clamping the cutter in the stem at about the proper diameter for the desired roughing cut. By manipulating the crank on shaft *A*, the turret slide is fed forward and back while this cutter is adjusted for diameter, until it is properly set. We then turn this diameter, feeding the cam drum by hand.

A facing tool, shown in action in Fig. 2, is placed at this station of the turret, being held in the turret hole. This consists, as may be seen, of a pilot bar clamped in the turret hole, carrying a circular body holding a facing blade. Feeding by hand, as before, this is adjusted lengthwise to rough face the work for the dimension desired. In a similar way, the finish turning and facing tools in the second face are set, the cam-shaft being revolved by hand to bring this second face and second cam into operation. The finishing facing tool is not shown in place in Fig. 3.

NEW MACHINERY AND TOOLS.

A MONTHLY RECORD OF APPLIANCES FOR THE MACHINE SHOP.

HEALD INTERNAL GRINDING MACHINE.

One of the many important developments of the automobile industry has been the new importance given to the operation of internal grinding. This operation has been proved to be a most practicable one for finishing holes accurately to size, in all sorts of work which at one time was thought to be best finished by the reamer. The reaming operation is a costly one, owing to the large expense involved in keeping the tools to size, requiring the purchase of new reamers if the solid type was used; if the adjustable variety is employed, there is always a slight variation in size due to the change in diameter

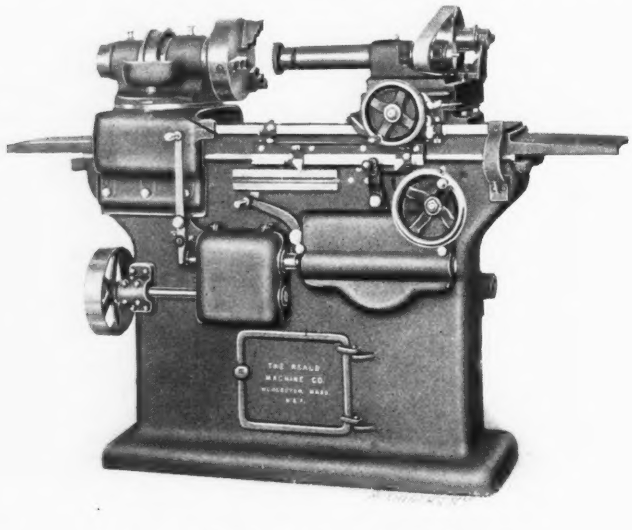


Fig. 1. The Heald Internal Grinding Machine.

that takes place before the necessary readjusting and regrinding is undertaken. Besides this, there is much work that is difficult to hold for reaming without distortion, because of thin walls which give under the pressure of the of the chuck jaws by which the work is held. The comparatively light clamping necessary for the grinding operation, and the light contact between the wheel and the work, permit the obtaining of holes much more nearly true and accurate to dimensions than is possible in any other way.

A good internal grinding machine will finish holes day after day, rapidly and true to size within 0.00025 inch (or closer if desired) directly from a rough bored cut, and without any expense for reamers for the various diameters, and without expense for keeping such reamers sharp. Besides this, it will finish to size, rapidly, holes in hardened steel parts, which cannot be reamed under any circumstances, and at a fraction of the time required for lapping them out.

Internal grinding has not always been done with all the rapidity and economy which the operation is capable of showing. This is owing to the fact that practically all internal grinding has been done on machines in which the wheel was supported by a structure in the nature of an attachment of the machine, instead of being an integral part of it. This usual construction (by which the wheel is supported on an over-hanging arm reaching forward from the wheel stand at the back of the machine) was so light and flexible as to encourage the vibrations which are one of the most serious troubles met with in grinding. The vibration of a spindle thus poorly supported breaks down the texture of the wheel, and makes it impossible for it to cut either rapidly or smoothly. Rigidity is the fundamental requirement in a successful internal grinding machine. The Heald Machine Co. of Worcester, Mass., believes that it has fulfilled this requirement in the internal grinding machine which we herewith describe and illustrate.

As may be seen, this tool is not an external cylindrical grinder modified for internal grinding, but is radically designed for the operation it is to perform. The bed is of simple and rigid form, provided with ways on its upper surface, on which slides a table carrying the wheel spindle. The work spindle head-stock is mounted on a frame which straddles the work table, and is fastened to the base on either side. A more direct and rigid construction it would be difficult to imagine.

The saddle or bridge on which the head-stock is mounted is of heavy design, as may be seen in Fig. 3. The head-stock *B* may be swiveled on it to any angle for grinding tapered holes, graduations being provided which read in degrees and in tapers per foot. Hardened bushing *C* is driven into *A*, and fitted carefully to *B*, furnishing a pivot about which the adjustment is made. The spindle is made of a special grade of high carbon steel, ground and lapped, and, as may be seen, is of generous diameter. It runs in tapered phosphor bronze bushings, adjustable for wear, and provided for suitable means for excluding dust and grit.

This spindle is driven by a belt from a 5-speed quick change gear box, which forms a part of the counter-shaft; by this mechanism correct work speeds for holes of different diameters are easily obtained, the changes being made much more quickly and easily than is possible with the cone pulleys ordinarily used. This encourages the operator to change the speed to suit the diameter of the work being ground, instead of (as is more often the case) using the same speed day after day on work of different kinds. It also permits him to instantly speed up the work during the finishing cut, to get the mirror-like finish possible with increased peripheral speed.

The cutter spindle is mounted on a cross slide for adjusting the wheel for the desired diameter. This cross slide, in turn, may be adjusted lengthwise of the table to bring the wheel in proper position for the length of work being ground. The cross slide carries a double idler pulley, of which the small diameter is driven from the counter-shaft, while the large diameter is belted to the driving pulley on the wheel spindle.

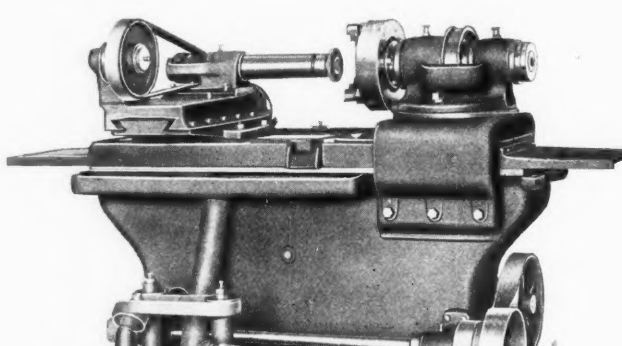
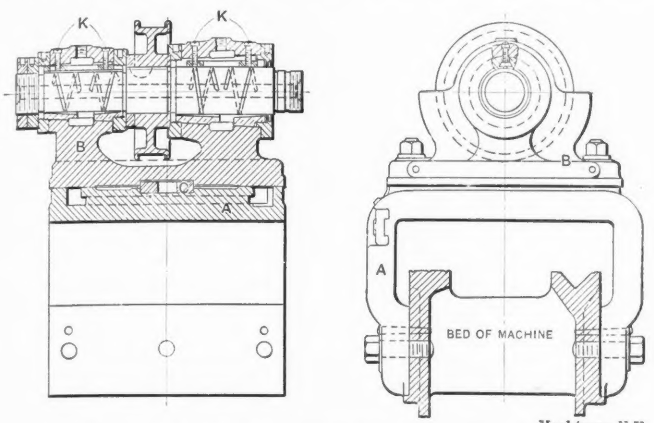


Fig. 2. Rear View of Machine showing Drive of Wheel Spindle and Provision for Wet Grinding.

The construction of the wheel spindle is shown in Fig. 4. The head *D* is held by a gibbed bearing to the cross slide. It supports the wheel spindle at three points—by two ball bearings on either side of spindle pulley *E*, and by a bronze bushing *F*, next to the wheel. This bronze bushing, which is tapered on its outside diameter, is adjusted in or out for wear by nut *G*; screws *H*, with tapered points, are used for expanding it to tightly fill the bore of the hole in which it is placed, thus giving a solid bearing without vibration, and fitting closely both the spindle and the head casting. The two ball bearings *J*, on either side of the driving pulley *E*, are suitably protected from dust and grit. The outer bearing is supported in such a way that an endless belt may be used.

connecting pulley *E* with the idler pulley. The stand on which the idler pulley is mounted is adjustable to maintain the tension on this belt.

Various sizes of heads *D* are provided for holes of different diameters. The regular line of heads is made in seven sizes, of which the smallest is suitable for a minimum hole of 7/8 inch diameter, while the minimum diameter for the largest size is 3 inches. These will grind holes varying in depth from



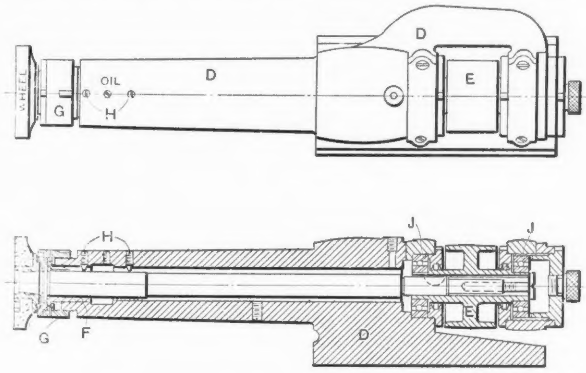
Machinery,N.Y.

Fig. 3. Work Spindle Head and Method of Supporting it on Bed.

a maximum of 4 inches long for the smallest, up to 11 inches long for the largest. The heads are self-contained and interchangeable, so that different sizes can be instantly substituted when changing from the grinding of large holes to small holes or *vice versa*. In shops equipped with several machines, the same head may be used on different ones, so that the expense of purchasing extra spindles is avoided. The diameter of the driving pulley on the different wheel spindles of these heads is made proportional to the diameter of the grinding wheels used, so that the correct speed for any given wheel is obtained automatically, without requiring any attention on the part of the operator.

The cross feed of the wheel, as may be seen in Fig. 1, is arranged to be operated either by hand or automatically, at either one or both ends of the table travel. Provision is made also for automatically throwing out this feed when the work has been brought down to size. The rate of feed may be varied from 0.00025 inches to 0.003 inch at each reversal of the table.

On the front of the base is mounted the automatic reversing gear box, and at the left the three-speed quick change gear box for giving the table three different rates of travel for each work speed. The feed is driven from the same shaft on the overhead works which drives the work table, so that the feed and work speed are always proportional—the proper arrange-



Machinery,N.Y.

Fig. 4. Axial Section through Wheel Spindle.

ment for the grinding machine, as for the lathe. The three different feeds provided and the easy means of changing them, encourage the operator to use the fast travel for roughing out the stock, and the slower rates for truing and finishing the holes. They are controlled by the vertical handle at the left end of the gear box. All changes of feeds and speeds are made from the front of the machine without stopping either the table, work, or wheel.

The provision made for the use of the water in this machine is carefully worked out, the table being provided with water channels leading to a water pan on the back. This tank is made unusually large, with an ample settling chamber, so that only clear water passes to the pump chamber and back to the wheel again. The pump is of the centrifugal type, so constructed that all the bearings are above the water, no packing or attention being required.

The builders consider that they have obtained in this machine the following essentials for rapid and accurate work: First, a massive and rigid design which will resist vibration, and give the wheel the ability to cut freely and smoothly. Second, suitable range of speeds of rotation for the work, covering the different sizes of holes, and materials to be ground, with means for changing these speeds instantly and easily. Third, a suitable range of table feeds for each of the spindle speeds, covering the requirements for roughing and finishing in different materials; these feed changes are also easily obtained. The design of the machine is, it must be admitted, a very attractive one.

BROWN & SHARPE GEAR-CUTTER GRINDING MACHINE.

We have previously called attention in MACHINERY to the necessity for grinding the faces of gear-cutter teeth radially, if the correct form of the cutter is to be preserved. With the common "rough and ready" method of grinding, in which the cutter is laid on a rest in front of a dish wheel, and ground by hand on the faces of its teeth, these faces may or

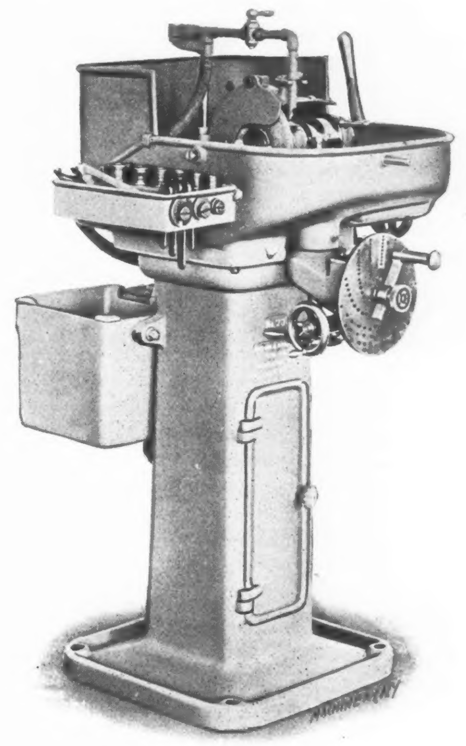


Fig. 1. Brown & Sharpe Wet Grinder for Formed Gear-cutters.

may not be radial. Usually they are far from it, and the tooth space produced is consequently too flaring if the cutter teeth are ground too far back at the tops, or the tooth spaces are as badly off in the other direction if the teeth of the cutter are "hooked." To provide means for grinding the cutter exactly radial, and doing it quickly, cheaply and conveniently, the Brown & Sharpe Mfg. Co., Providence, R. I., is building the grinding machine which we herewith describe and illustrate. As well as providing for grinding the cutter radially, it also spaces the grinding of the faces accurately, so that the teeth are always of the same height, thus allowing each one to do its share of the work, and permitting the maximum output from the cutter.

Fig. 1 shows the front view of the machine as a whole, and gives a very good idea of the design, which, it will be seen, gives great rigidity and freedom from vibration, in combination with a very moderate weight. Fig. 2 shows the right-hand side, and illustrates the compactness and convenient ar-

rangement of the operating mechanism. This mechanism is best understood by referring to the line drawings, Figs. 3, 4 and 5.

The cutter to be ground is dropped onto the hollow work spindle *A*, the open side clamping washer *B* being slipped from beneath the head of clamping bolt *C* for that purpose. A spring bearing against a shoulder in *A* keeps the clamping bolt forced upward, except when it is drawn down onto the

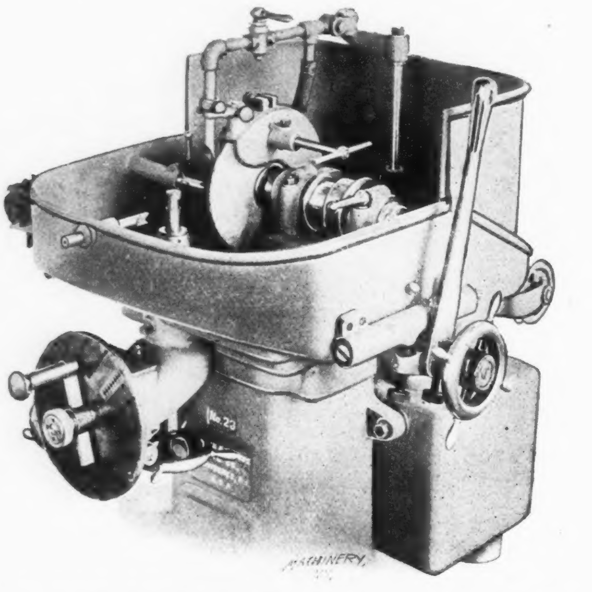


Fig. 2. Details of the Wheel Feed and Work-holding Arrangements.

work by revolving the work clamping hand-wheel *D*. Various bushings are provided for the work spindle, to suit various diameters of holes in the cutters; and various washers are provided to bring the center of the cutter in the horizontal plane of the axis of the wheel. The centering of the cutter is tested by the work centering gage *E*, which is pushed in until the V-groove in its end rests on the point of the cutter tooth. The centering need be only approximate.

Index crank-shaft *F* is connected with the work spindle by bevel gears, as shown, and carries an index crank and pin similar to that used on the index centers of the milling machines. The index crank can be moved from one row of holes to another in the usual fashion, being tightened by the clamp nut shown on the end of the crank-shaft. Index plate *G* is provided with 9 rows of holes, for obtaining any number of settings up to 18. It is keyed to the hub of a worm-wheel, and is operated by a worm connected with the work spindle adjusting wheel *H*. Wheel *H* is used to rotate the work into posi-

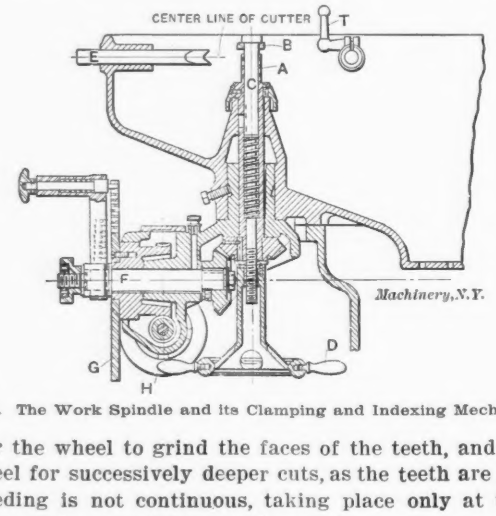


Fig. 3. The Work Spindle and its Clamping and Indexing Mechanism.

tion for the wheel to grind the faces of the teeth, and to feed the wheel for successively deeper cuts, as the teeth are ground. The feeding is not continuous, taking place only at the end of each complete revolution of the work.

The emery wheel, which is of the dished variety, is mounted, as may be seen in Fig. 4, on a spindle driven by a two-step cone pulley. The wheel spindle head-stock is adjustable in the direction of the center line of the spindle, as will be explained later, for centering the wheel so that it will grind the faces of the teeth radially. The base on which the head-stock is mounted slides in and out, toward and away from the work, being actuated by a rack, and a segmental gear *M*, keyed to a rock-shaft on which is mounted hand lever *N*. This hand lever is not directly connected with the rock-shaft, but has clutch teeth formed on its hub, which engage similar teeth in the hub of the wheel slide adjusting hand-wheel *O*, which is keyed to the shaft. The clutch teeth are kept in contact by the spring shown. By pulling the hand-wheel out, turning it in relation to the lever, and re-engaging it, the lever may be brought into any desired relation with the position of the wheel slide, to make the operation of the machine convenient. As is best seen in Fig. 2, the hub of the hand lever is provided with lugs carrying adjustable stop-screws *P* (Fig. 4) which are set to limit the movement of the slide when in operation, so that the wheel grinds to the proper depth in the cutter, and is allowed to come far enough out of the cutter to permit it to be indexed for the next tooth. Spring plunger *Q* keeps the wheel slide normally in its backward position.

Provision is made for thoroughly flooding the work with water while it is being ground. A centrifugal pump of simple construction is provided with all its bearings above the water line. Convenient piping, settling tanks and reservoir are included with the machine, so that water is kept off the floor and from all those parts of the machine where it does not belong. The water is strained and returned to the reservoir ready to be used over again. A number of other conveniences are provided. In the side of the water pan is cast a boss with a clamp handle *T* for holding a diamond tool in truing the wheel. This diamond tool is adjusted to the proper position while the wheel is fed back and forth across it by lever *N*, as when grinding cutters.

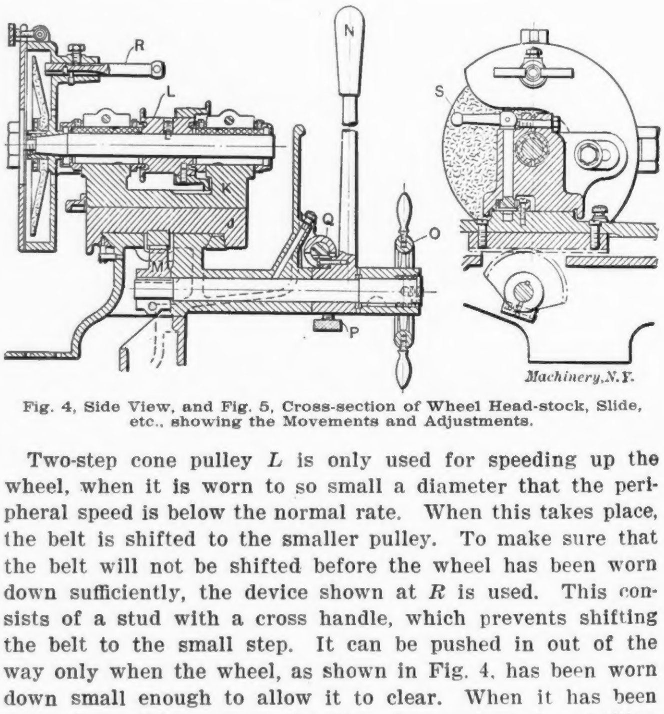


Fig. 4, Side View, and Fig. 5, Cross-section of Wheel Head-stock, Slide, etc., showing the Movements and Adjustments.

Two-step cone pulley *L* is only used for speeding up the wheel, when it is worn to so small a diameter that the peripheral speed is below the normal rate. When this takes place, the belt is shifted to the smaller pulley. To make sure that the belt will not be shifted before the wheel has been worn down sufficiently, the device shown at *R* is used. This consists of a stud with a cross handle, which prevents shifting the belt to the small step. It can be pushed in out of the way only when the wheel, as shown in Fig. 4, has been worn down small enough to allow it to clear. When it has been worn down this amount, the time has arrived for shifting the belt. This prevents the possibility of running the wheel at a dangerous rate. The wheel is provided with a guard, as shown, to prevent accidental breakage of the wheel or injury to the operator.

The centering of the wheel is simply effected by the method indicated in Fig. 6. The center gage is laid against the trued side of the wheel, and the slide is adjusted (by means of lever *S* in Fig. 5) in or out until the surface of the gage just touches the body diameter of the work clamp bolt. When the gage just touches this point as it rests on the face of the wheel, the wheel is exactly centered with the work spindle.

The stand is of box form, rigidly braced internally to resist vibration, and its interior is fitted up as a closet to hold small tools. A finished pad is provided at the back of the stand for attaching a motor when desired. The water pan is a separate casting securely bolted to this stand, amply large

enough to take care of all water used. The back is cut away and a removable sheet iron guard, heavily japanned, is provided to facilitate cleaning.

This machine will grind cutters up to 8 inches in diameter, 1½ inch pitch and 2¼ inches thick, using an 8-inch emery wheel with 1¼-inch hole. The work spindle and the bushings provided are arranged to fit holes ⅞, 1 1-16, 1¼, 1½, and 1¾ inch in diameter, respectively. The counter-shaft is provided

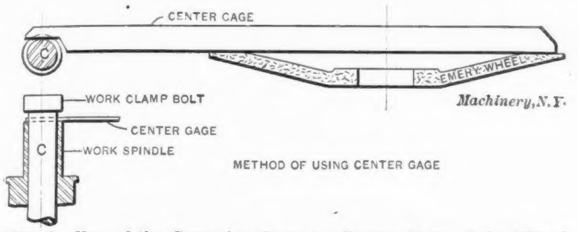


Fig. 6. Use of the Centering Gage in aligning Face of the Wheel with the Center Line of the Work.

with tight and loose pulleys 6 inches in diameter for 2-inch belt, and should run at 600 revolutions per minute. The net weight of the grinder is 760 pounds. It occupies a floor space 33 inches wide, parallel to the wheel spindle, and 39 inches long, perpendicular to the spindle.

REVOLVING OILSTONE SCRAPER SHARPENER.

The revolving oilstone grinding machine, made by Mummert, Wolf & Dixon, of Hanover, Pa., which we have previously described (see New Machinery and Tools in the June, 1907, issue of MACHINERY), has been adapted by the builders to the sharpening of scraping tools.

Figs. 1 and 2 show it so arranged. It is claimed by the builders that scrapers sharpened on this machine are much superior to those sharpened by the usual hand method on a bench oilstone. It is said that the scraper will not only be sharpened quicker and better, but in such a way that it will cut better and longer without resharpening, and in such a way as to enable an inexperienced man to get the greatest efficiency out of the tool.

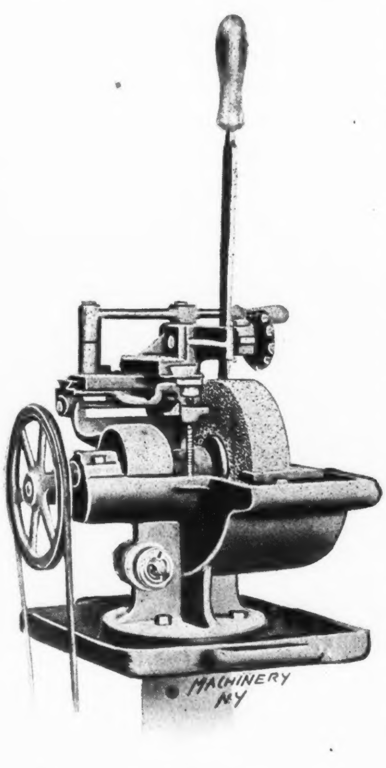


Fig. 1. Revolving Oilstone sharpening a Machine Scraper.

In the first place, the device may be used for concaving the faces of the scraper in much the same way that a razor is concaved, to prevent the cutting edges from displaying their tendency to become so obtuse that the tool will not work unless held at a considerable angle with the surface being scraped. By concaving the scraper in the way shown in Fig. 3, a much freer cutting edge is obtained.

For grinding the edge, as shown in Fig. 1, the scraper is held in a vise supported by suitable slides. By the use of the hand lever, the scraper is moved back and forth as well as laterally across the face of the stone. By these two motions the tool is ground all over the cutting edge, and the stone is kept straight as well. For gripping the scraper quickly and accurately in the vise, a small reference surface is provided which is always in line with the face of the wheel, and parallel with the lines of the motion of the two slides. To use this, the scraper is first pushed over this reference surface; the scraper is set to it, and then gripped by turning the small hand-wheel shown, after which the vise is pushed laterally forward until the scraper comes over the stone. The feed is regulated by the adjusting screw shown at the front of the machine.

This revolving oilstone may be used for other purposes besides sharpening scrapers—such as touching up and putting a keen, smooth edge on thread cutting or other tools on which a fine edge is required. In doing work like this, the scraper holding attachment is thrown back out of the way, as shown in Fig. 2. The wheel is run in a bath of kerosene, which prevents heating the tool and keeps the surface of the wheel keen and sharp, without allowing it to glaze. In the design shown, the wheel is driven by a motor, connected by a belt with the driving pulley, which transmits the power to the wheel through two-to-one gearing. The motor, which is of ⅛ horse-power capacity, is furnished for either direct or alternating current.

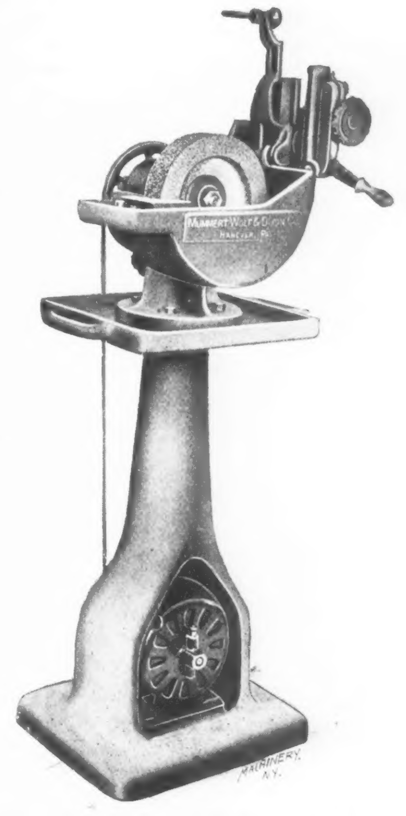


Fig. 2. Scraper Holding Device thrown Back, leaving Wheel Free for General Use.

When electrically driven, the tool is especially adapted to the work of grinding scrapers, as it is provided with two handles by which it may be easily carried by two persons and placed close to the work on which the scraping men are engaged. When desired, it will be furnished with a counter-shaft and belt drive, instead of a motor as shown.

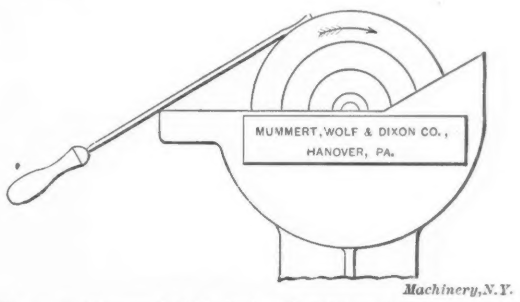


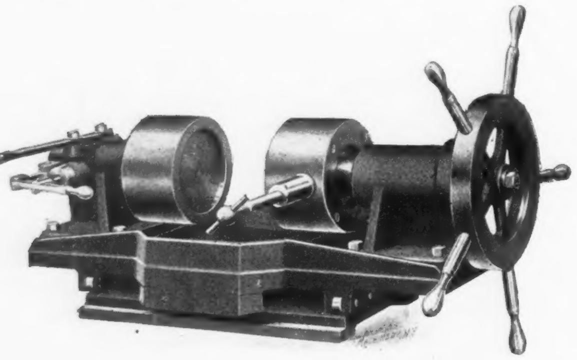
Fig. 3. Recommended Method of Concaving Scrapers to give Free Cutting Action.

MURCHEY REVOLVING CHUCK FOR DRILLING AND TAPPING.

The accompanying half-tone illustrates an improved revolving chuck, designed for holding steam, gas, or water fittings, and valves, and adapted for use on a vertical drill press or tapping machine. This chuck is made by the Murchey Machine & Tool Co., 4th and Porter Sts., Detroit, Mich. The following description will make clear the points of improvement claimed for this chuck over former designs:

The work is held between the two cylindrical clamping heads shown at the center of the machine, the final clamping action being accomplished by means of the pilot wheel to the right. When the work is removed, this pilot wheel is first given a slight turn, enough to release the pressure on the work and on the indexing pin attached to the lower lever shown at the left-hand end in the cut. The indexing pin, which serves the purpose of taking the end thrust as well as preventing the clamping heads from rotating while the work

is operated upon, is now withdrawn, and finally, the left-hand clamping head is moved back by the upper lever at the left end, which quickly opens the chuck and permits the work to be removed. This improvement considerably lessens the time required for removing and inserting work as compared with the old style chucks having right-hand and left-hand screws.



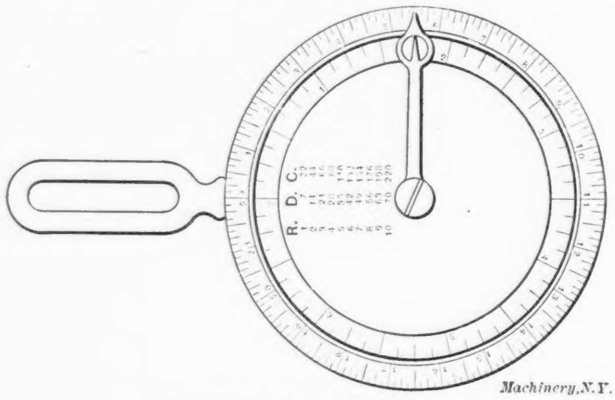
Murchey Revolving Chuck for Drilling and Tapping Valves, Pipe Fittings, etc.

The several faces of the fitting are drilled and tapped at one setting of the work, the indexing mechanism permitting the work to be turned to any required angle.

The rollers shown at both ends of the device under the bed plate of the chuck, between it and the base, are intended to permit the work to adjust itself easily to the position of the drill, and also permit the operator to pull the chuck easily from under the drill press spindle for removing the work.

JONES DIAL MEASURING WHEEL.

The illustration shows a dial measuring wheel designed for the use of boilermakers, blacksmiths, and plate metal workers. Diameters and circumferences are simultaneously obtained by setting the indicator at zero and running the wheel around the circumference of the piece to be measured. The pointer is made double, and indicates diameters on the inner



Jones Dial Measuring Wheel.

circle and circumferences on the outer one. The wheel is made of brass with raised and polished figures, letters, and graduations. The handle is mounted on the back, thus leaving the face of the wheel free of obstruction. The wheel is 7 inches diameter and 22 inches circumference (nearly). It is made and sold by J. M. Jones, 1560 Cambridge St., Cambridge, Mass.

STURTEVANT STEAM-TURBINE-DRIVEN FOUNDRY BLOWERS.

The Sturtevant steam turbine, which we illustrated and described in the New Machinery and Tools Department of the November, 1907, issue of MACHINERY, has been arranged by its builder, the B. F. Sturtevant Co., of Hyde Park, Mass., in combination with its line of foundry blowers, in a series of self-contained units. These turbine-blower units are especially suitable combinations for foundry use, since the driving of the foundry blowers by either steam engine or motor presents numerous difficulties of operation, all of which are overcome in the steam turbine.

With a blower driven by a reciprocating engine, the connection between the two must, of necessity, be by belt or some other speed increasing mechanism, since the high pressure required for foundry service demands a high rate of speed for the blower. Usually a counter-shaft is employed to give the necessary increase. Another difficulty is the chance of having the engine disabled by water coming over from the boiler in the long pipes which must be used. This danger may, of course, be minimized by the use of separators, but it is always in existence. There is, besides this, the liability to wear and break down, due to the somewhat complicated mechanism of the valve gear, piston, cross-head, etc.

The electric motor is generally used in preference to the engine, where there is a supply of electricity, the motor being usually connected with the blower by belting. Due to the

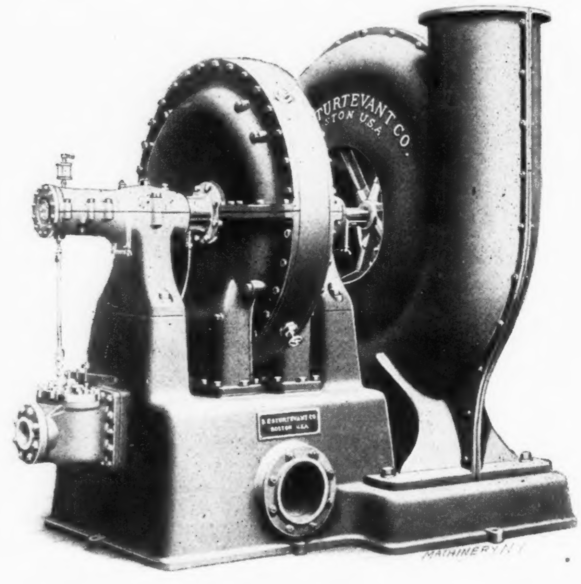


Fig. 1. Sturtevant Steam Turbine and Foundry Blower Set.

varying volume and pressure of air required, it is difficult to fit an electric motor for the conditions under which the blower will have to operate, since it is often impossible to determine these in the beginning. Besides this, the motor will deteriorate rapidly in the heat and dust of the foundry atmosphere, and usually has to be placed in a room of its own, or be removed to a considerable distance from the cupola.

In a steam turbine, such as is shown in Fig. 1, the difficulties of both the reciprocating engine and the motor are believed to have been obviated. It can be continuously operated, without attention, requiring only a weekly filling of the oil cups. The entire absence of mechanism makes the cost of

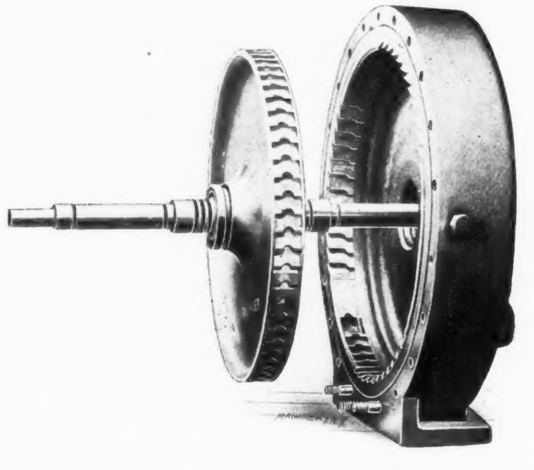


Fig. 2. The Runner of the Turbine withdrawn from the Casing to show the Solid Buckets.

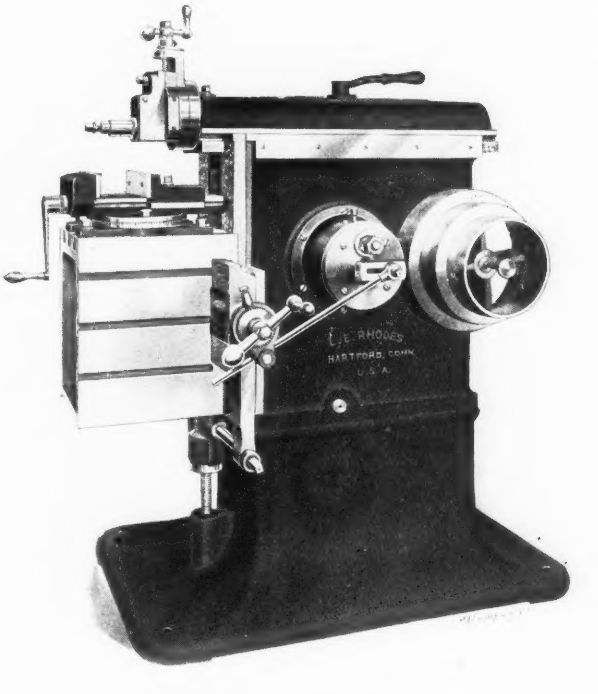
renewals and repairs so small as to scarcely have to be reckoned with. There are no valves to set or eccentrics to adjust. Although the reciprocating engine is as economical, the steam consumption is not the true measure of ultimate economy. When other items, such as repairs, deterioration, etc., are considered, the builders believe that the turbine will prove ultimately more economical than the reciprocating engine.

The wheel, removed from the casing, is shown in Fig. 2. The buckets are cut from the solid forging, not being separate pieces as in many turbines now on the market. A single solid wheel is used, in which the steam is used over again a number of times, so as to reduce the peripheral velocity of the wheel, and at the same time abstract all available energy from the steam before it escapes into the exhaust. For a more detailed description of the action of the steam in this turbine, see the article in MACHINERY previously referred to.

RHODES 12-INCH BACK-GEARED CRANK SHAPER.

The back-geared crank shaper shown herewith is built by L. E. Rhodes, of Hartford, Conn. Its special feature, aside from its small size and convenient arrangement, which fit it for tool-room work, is the fact that it is provided with back-gearing for varying the ratio of the connecting gearing between the cone pulleys and the crank. This is an unusual provision for so small a machine. Six changes of speed are furnished in all, with the three steps provided on the driving cone. The back-gear change is made by pushing the knob shown in the cone pulley either in or out, as may be required. This shifts a double driving pinion on the driving shaft, so that either its large or small diameter engages with gears on the intermediate shaft, by which it is connected to the crank gear.

The machine is provided with a suitable vise, as shown, having tool steel faced jaws 9 inches long and 2 inches deep,



A Small Back-geared Crank Shaper.

opening 6 inches. The finest table feed is 0.005 inch. The table is fastened to the cross rail by a wedge-shaped gib, thus insuring a bearing surface through its whole length.

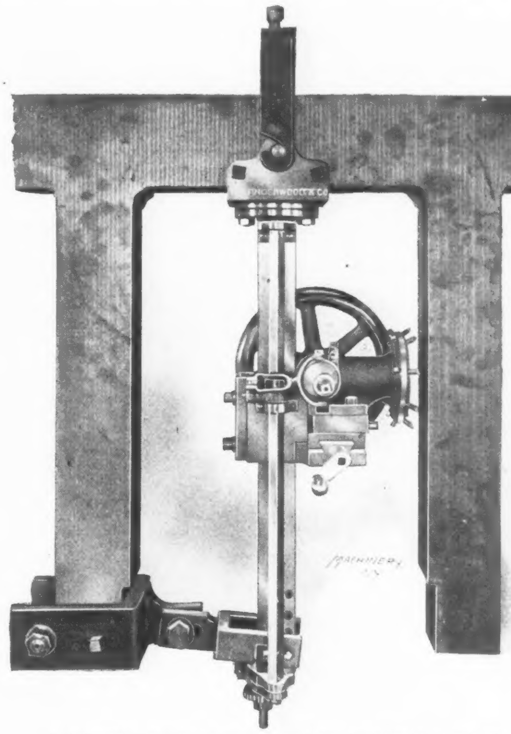
The stroke of the ram is 13 inches, the vertical adjustment of the table 12 inches, and the traverse of the table 18 inches. The working surface of the table is 11 x 13 inches. The machine is driven by a 2½-inch belt. The weight of the machine, complete, is 1,650 pounds.

UNDERWOOD PORTABLE FACING MACHINE FOR LOCOMOTIVE FRAME PEDESTALS.

H. B. Underwood & Co., 1024 Hamilton Street, Philadelphia, Pa., have recently added another tool to their list of portable devices for general railroad and machine shop use. This new tool, as may be seen in the accompanying half-tone, is designed for facing the inner surfaces of the pedestal legs on locomotive engine frames.

The milling head by which the facing is done is carried by a square bar, which is the main supporting member of the mechanism. This bar is provided at the top with a steel swivel connection to the clamping block by which it is fastened to the frame. This steel swivel allows the cutting tool to be swung around for cutting the other side of the opening, and also allows the square bar to be set at an angle for facing on a taper. The clamping block may be easily changed to enable it to enter narrow spaces. At the lower end of the square bar the universal adjustable clamp holds it securely to the frame.

The milling head is fed along the square bar by a bronze half nut, which may be engaged with, or disengaged from the



A Portable Machine for Facing the Pedestal Jaws of Locomotive Frames.

feed-screw. This screw is revolved by a ratchet and dog at the lower end of the device, operated, through the squared shaft shown, by an eccentric on the milling head. The feed is thus automatic, and may be varied to suit the requirements. The milling spindle has adjustments in two directions—to and from the leg, and across the face. Fine or rapid adjustments may be made without difficulty, suitable cranks being provided for obtaining these movements.

The milling spindle is threaded to receive the milling cutters, which have blades of square high-speed steel, set in a solid head; they are removable for grinding or adjustment. The power is applied by a telescopic shaft with universal joints, operating through gearing on the spindle, and allowing the source of the power to be in any convenient, out of the way place, making belts, etc., unnecessary. The maker's two-cylinder air or steam motor is a very suitable prime mover for a portable tool of this kind.

In using this machine, a large quantity of metal can be removed in a given time, by taking a succession of light cuts and feeding very rapidly.

GOULD & EBERHARDT RACK-CUTTING MACHINE.

We illustrate in Figs. 1 and 2 a new design of rack-cutter built by Messrs. Gould & Eberhardt, of Newark, N. J. This machine has been improved in a number of particulars over the designs formerly built, adapting it to faster and heavier cutting and greater accuracy. It is designed with a view of obtaining to the fullest extent the benefits to be derived from the use of high-speed steel cutters, and at the same time give a product of the highest degree of accuracy required in commercial work.

One important change has been made in the design of the bed of the machine. This was formerly of rectangular form, supported by box legs. The new construction is solid in one piece, resting directly on the floor, thus taking directly all

strains from the action of the cutters on the work. That part of the bed which supports the cutter slide column is also cast solid with the main bed casting, still further adding to the rigidity of the entire machine. Another improvement consists in arranging the thrust bearings of the feed-screw so that the cutter slide is pulled down, as it feeds through the work, on the draw-cut principle. This, in connection with the style of bed furnished, insures not only increased feeds, but greater accuracy as well.

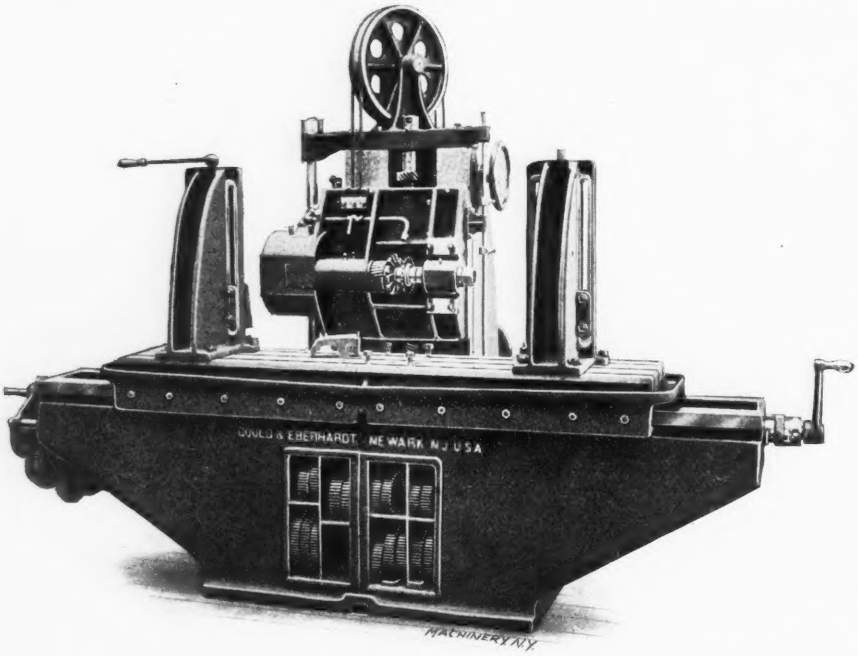


Fig. 1. A New Design of the Gould & Eberhardt Rack-cutting Machine.

The cutter slide is counterbalanced, and is so arranged that it cannot possibly feed downward unless the proper indexing for the work and all previous necessary movements have been completed. The cutter spindle is located approximately in the center of the slide, which has a large bearing surface, giving freedom from chatter under heavy work. The cutter spindle is driven by double spiral gears, one pair placed at the outboard end, and the other close up to the cutter, where the full driving effect can be obtained. One of these pairs is cut right- and the other left-hand, thus neutralizing by this herringbone gear effect the end thrust in the cutter spindle. The guard over the inner driving gear has been removed in Fig. 1 to show this drive.

The feeds for the cutter slide range in geometrical progression from ¾-inch to 14½-inch per minute, thus providing a range that will economically take care of all classes of work. The spindle drive, feed motion and the indexing are all derived from the single speed driving pulley at the rear. This makes the matter of changing to individual motor drive a very simple one. The feeds are obtained by quick change gear mechanism, shown next to the driving pulley in Fig. 2. The cutter speeds are varied by the change gears shown at the end of the rear extension of the bed. These cutter speeds vary from 12 to 76 revolutions per minute, in geometrical progression.

The work table is provided with chucks or vises for holding the work. These vises are so designed that they are fastened solidly, metal to metal, to the top of the table, thus avoiding the common fault of springing or warping the latter out of line. The table has a generous bearing surface, and is strongly gibbed to the ways on the main bed casting. The vertical position of the blanks and the vertical travel of the cutter slide, permit chips and oil to drop down out of the way of the cutters, leaving the work free. An opening in the bed of the machine is provided, through which the chips and lubricant are drained, being separated by suitable screens so that the oil is returned to the pump and the cutters, free from chips.

The indexing mechanism for the table is simple and absolutely positive in its action, reducing the chances of error to a minimum. One novel feature is the provision for the insertion of translating gears for changing the setting of the machine from diametral to circular pitch or *vice versa*, or to set it for cutting metric module or circular pitch—all with the same lead or dividing screw. An auxiliary end adjustment for the screw is provided which is useful in resetting work which has to be recut, or for taking a light cut on one side of the tooth. The table is geared to index in either direction, avoiding the necessity for returning the table every time a new blank is set. Adjustable stops are provided which can be set at any predetermined point, to automatically throw out the table indexing movement.

The machine shown, which has a capacity of work up to 6 feet long at one setting, was furnished to a large planer manufacturer for cutting the planer table racks. Duplicate machines from the same lot have been furnished to other manufacturers of machine tools, printing presses, etc. This tool will cut any width of face up to 10 inches, or a series of narrow-faced racks up to the same width. Any pitch as coarse as 1½ diametral in cast iron, or 2 diametral in steel may be cut, using from 1 to 12 cutters, depending on the pitch. It is possible to use a roughing and a finishing cutter at the same time on the largest pitch mentioned above. Gang cutters provided with this machine have their cutting points set spirally, so as to avoid chatter and the consequent rapid dulling of the cutting edges. A bed and table for work up to ten feet in length at a single setting will be furnished if the purchaser requires it.

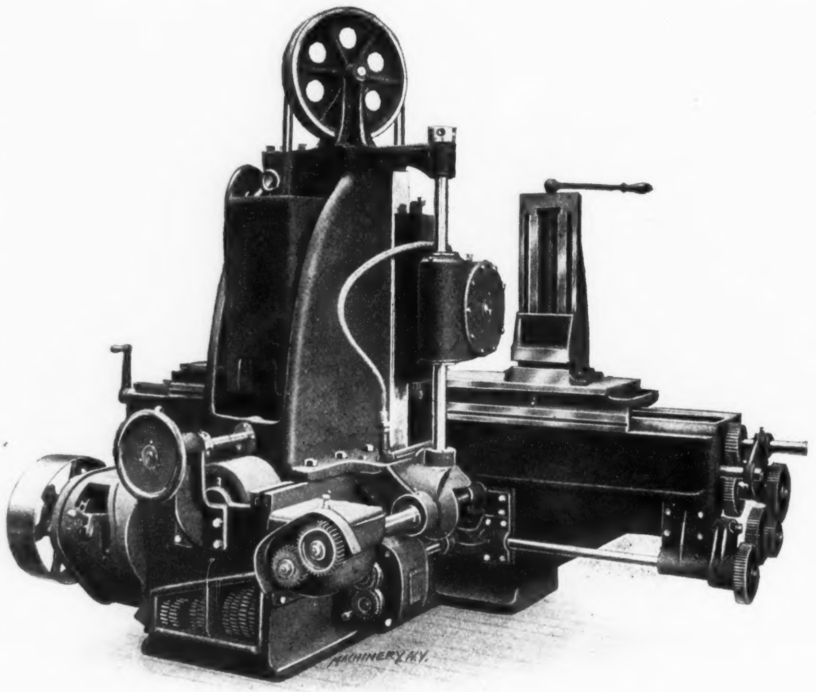


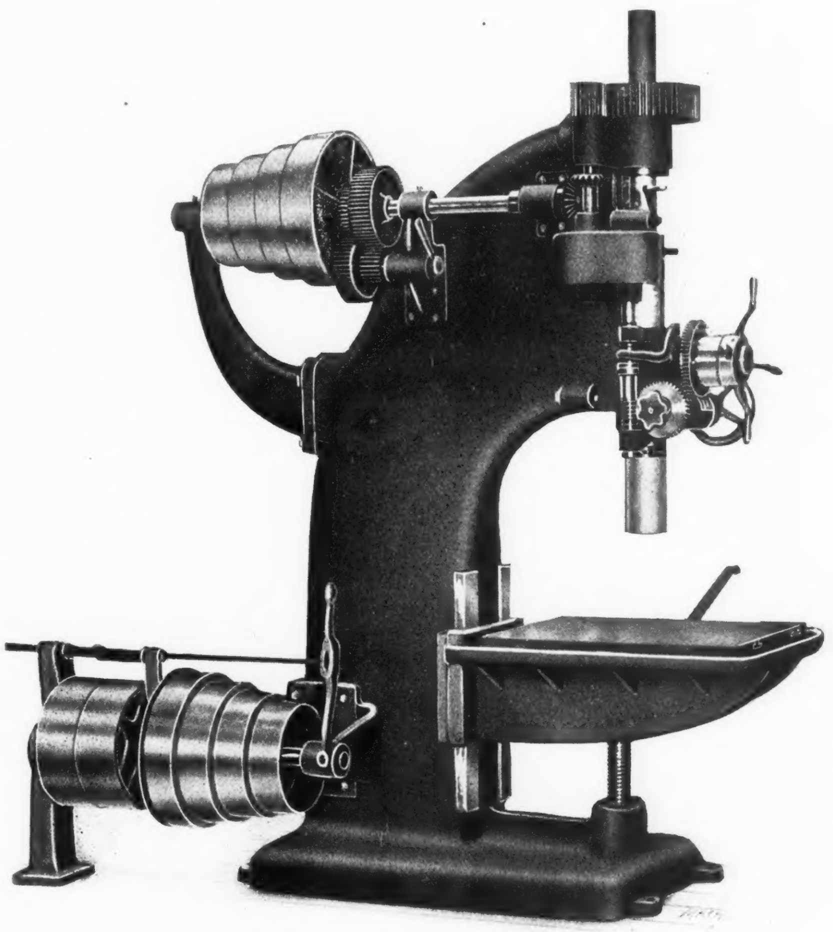
Fig. 2. Rear View of the Machine, showing Single-speed Drive, Quick-change Gear Feed, Indexing Mechanism, etc.

It will be seen that this machine in its structural features belongs with the other Gould & Eberhardt machine and the Reinecker machine, shown in Figs. 69 and 70 of the article on

gear-cutting machinery (on page 509 of the engineering edition of this issue) though it differs considerably in its mechanism from either of them.

FOOTE-BURT HIGH DUTY DRILL PRESS.

It used to be considered that, for drilling tools, all it was necessary to have was a revolving spindle, properly driven, and a table on which the work could be placed, having a surface approximately perpendicular to the axis of the spindle. Carefulness of workmanship, strength and rigidity of frame, and other such features as are looked out for in the design of lathes, planers, milling machines, etc., were once thought to be a waste of time and money when applied to drilling machines. Of recent years, however, this attitude has changed, since it has been found that drills, particularly of the modern high-speed type, can be worked harder, and will remove more material in a given space of time, when driven by a heavy, rigidly built machine, than when used in a tool of the older type; heavier feeds can be taken, and the cutting edge lasts longer. Recognizing this condition, the Foote-Burt Co., of Cleveland, Ohio, has brought out the drill press shown in the accompanying engraving.



A Drill Press for Heavy Duty with High-speed Drill.

The spindle is of forged carbon steel, 3½ inches in diameter in the sleeve, with a No. 6 Morse taper hole. The thrust of the cut is taken by a bearing of ¾-inch balls which is made in the shops of the builder, and is guaranteed to stand up under the hardest service continuously, without breaking the balls or crushing the collars. The spindle is driven from a four-step cone, through bevel and spur gears and a set of back gears, which, in combination with the cone pulleys, give eight changes of speed to the spindle.

Three changes of gear feed are provided, any one of which is instantly available by simply shifting a lever conveniently located at the front of the machine. The power feed, hand worm-feed, automatic stop and quick return levers are all within easy reach of the operator at all times.

The maximum distance from the end of the spindle to the body of the table is 32 inches, the distance from the center of the spindle to the face of the column is 22 or 30 inches (as may be ordered), and the spindle has 16 inches of power feed. The revolutions per minute vary from 23 to 170. Either a plain or a compound table movement may be furnished. The 44-inch swing size weighs 6,000 pounds, and the 60-inch swing 6,800 pounds. The machine is powerful enough to drive a 3½-inch high speed drill up to its full capacity.

HILBERT TRIPLE-GEARED UPRIGHT DRILLING MACHINE.

As may be seen from the accompanying engravings, the designer of this drill press (which is built by the Hilbert Machine Co., Cincinnati, Ohio) has broken entirely away from the traditions of the standard drill press builder. Everything, from the shape of the frame to the method of driving, has been worked out on original lines. The designer's reasons for these changes will appear in the following description.

The frame consists of a round column of generous dimensions, provided with a large bottom flange, bolted to a heavily ribbed T-slotted base. This column is supported by a second column or back brace, which connects the base and the top housing, making these four members solid.

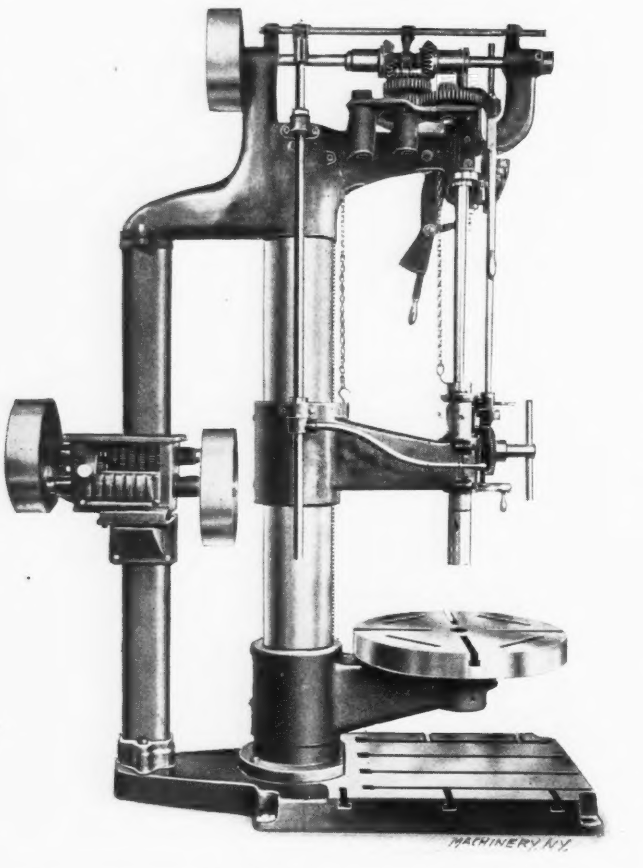
The work table is fixed in height, avoiding the raising and lowering mechanism usually provided. Instead of this, the arm carrying the lower spindle bearing is adjusted up and down on the column. This has a long bearing, and surrounds the column, sliding down on the latter to the top of the table arm, when the nose of the spindle will nearly touch the base. These two arms for supporting the table and the spindle are of box shape, and of nearly the same pattern. Each is clamped securely to the column by means of two strong screws, insuring the rigidity of the structure of which they are a part. This arrangement is believed by the builders to be superior to the usual method of fastening the lower spindle bearing to the frame work by screws and flat bearings, so far as concerns the matter of obtaining the necessary rigidity for heavy duty work.

The machine is connected to the countershaft by a belt to the single speed pulley, shown attached to the speed variator on the rear column. This single pulley allows the machine to be set in any direction under the line shafting, either at right angles with it or parallel to it. The speed variator is of the most simple type, and is operated with one lever only, giving six speeds arranged in geometrical progression. From here, the power is carried by belt to the shaft on top of the machine. This belt serves as a safety device in the otherwise positive power transmission system, preventing the breakage of the drilling or boring tools. The six speeds given by the variator are multiplied by three, by the operation of the handle shown in front, depending from the upper spindle bearing. This lever is conveniently located for the operator, and its position can be changed instantly.

The spindle is driven by either one of two gears, a large one with a coarse pitch for the slowest speeds and a small one with finer pitch for the higher speeds. None of these gears run idle. When the back gear is thrown in, the gears of the medium and high speeds are thrown out, and *vice versa*. Having this change of speed directly on the spindle, allows all the shafts of the machine to rotate slowly when the spindle speed is high, as contrasted with the great rate of rotation necessary for the horizontal shaft in the usual type of upright drill, with its bevel gear drive ratio of one to two or one to three. In such cases the shafts have to rotate two or three times faster than the spindle.

Another feature of this machine is the design and location

of the tapping mechanism provided. Instead of being applied directly to the spindle drive, as usual, where the torque is at the highest point, it is located on the high speed driving shaft. It consists of two miter gears, provided with friction clutches which are adjustable for wear. The clutches are so designed that they tighten in proportion to the load placed on them. Either of these friction clutches may be connected



An Upright Drill of Original Design, made by the Hilbert Machine Co.

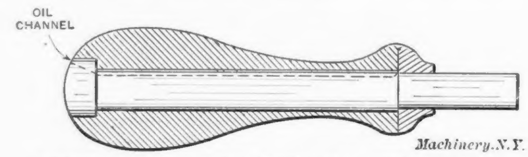
with its miter gear by means of the horizontal handle shown, pivoted to the lower spindle bearing head, and operating the vertical squared shaft, which transmits the movement to the clutch. This lever is directly in front of the operator, and is used by him for stopping, starting and reversing the machine, as well as for tapping. Owing to the use of the friction clutch, the reversing of the spindle may be done at any speed. These clutches have proved to be reliable in actual use, having been in operation for over six years without requiring any adjustment for wear.

The power feed is the positive gear type, having four changes. It is very powerful and constructed in a mechanical manner. It is quickly and easily changed by the handle shown in the engraving, hanging from the upper bearing of the spindle on the further side of the machine. Hand feed and quick return movements are provided for the spindle, as well as an automatic trip, adjustable to work at any point throughout the travel of the spindle.

The machine shown is the standard type furnished by the builders, and is of 36-inch capacity. As shown, it is regularly provided with the tapping attachment. It is built in a workmanlike manner; all the important gears are of steel and all the important bearings are of phosphor-bronze.

CINCINNATI QUICK-ACTION BALL CRANK.

The Cincinnati Ball Crank Co., of Cincinnati, O., has been for some years manufacturing solid crank handles for machine tool builders, for general use on cranks, hand-wheels, etc. It has recently added to this line of solid handles, a "quick action" design of the type shown in the accompanying line engraving. As may be seen, it consists of a central pin which is riveted or otherwise fastened to the crank or balance wheel, and carries a washer, and a loose handle or spool, which is grasped by the hand of the operator. Since this handle revolves freely, the workman is able to use it much more quickly and easily than would be the case if it were solid. It will be found especially adapted to heavy tools, being useful, for instance, for such applications as to the carriage movement of a large lathe. The rotation of the



Machine Crank or Wheel Handle with Revolving Grip.

handle makes it possible to operate such machines with the ease and rapidity of tools of much smaller size. As is shown, an oil channel is provided, by means of which the handle can be lubricated.

CYLINDER GRINDING ATTACHMENT FOR THOMPSON GRINDING MACHINE.

The accompanying Figs. 1 and 2 show a method of holding automobile cylinders and similar work for internal grinding operations, which is much superior to any possible method of clamping it to a face-plate or holding it in a chuck. Fig. 1 shows the device mounted on the table of a grinding machine built by the maker of the attachment, the Thompson Grinder Co., of Springfield, O. Fig. 2 shows the device in action, with the work in place.

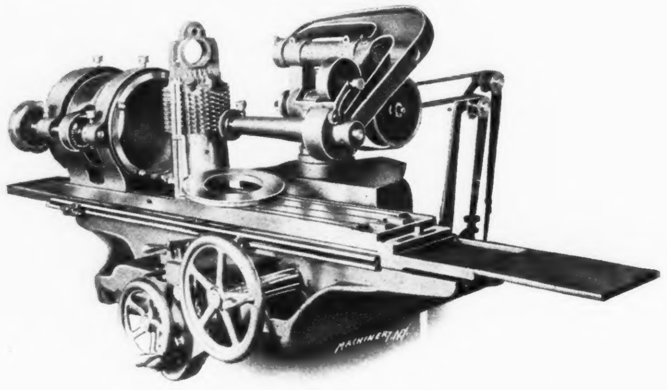


Fig. 1. Hollow Spindle Head-stock for Grinding Automobile Cylinders in Thompson Grinding Machine.

As will be seen in the engravings, the front end of the work is held in a face-plate, bored to the same size as the recess of the crank-case, thereby holding it without any possible chance of springing it in clamping. This face-plate, in turn, is bolted to the face of the hollow spindle, which runs in generous bearings, with suitable provision for adjust-

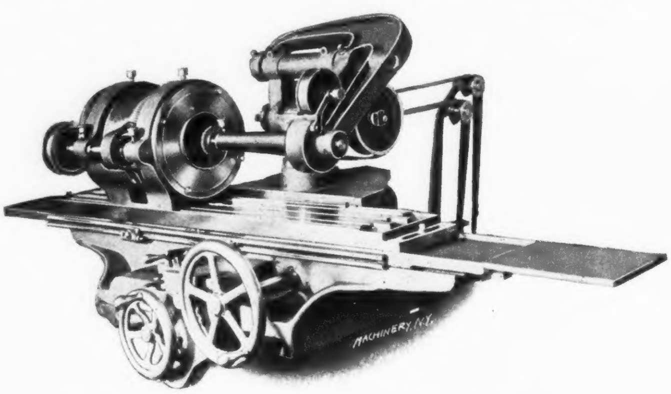


Fig. 2. Cylinders in Place in Hollow Spindle Attachment and Grinding in Progress.

ment for wear. It is driven by gearing from a fast-running shaft. The diameter of the hole in the hollow spindle is 10 inches. At the rear end of the attachment, appropriate means are provided for supporting the closed end of the work.

The cylinder shown on the table of Fig. 1 is of the air-cooled type, and is 5½ inches bore by 11 inches deep. In this machine the internal grinding spindle is of tool steel, hardened and ground, and running in adjustable bearings, by which all lost motion is taken up, except that necessary

for the lubricating oil. It is driven by an endless cotton belt, held at the proper tension by the idler seen in the engraving, thereby securing long life to the belt and bearings. As the machine is regularly provided with pumps, pipes, etc., for wet grinding, provision has also been made for using water with this attachment when desired.

INCLINED BLISS PRESS WITH DOUBLE DIE ATTACHMENT.

The press shown in the accompanying engraving is built by the E. W. Bliss Company, 5 Adams Street, Brooklyn. It is fitted with tools for blanking, drawing and wiring shallow cups or similar shaped work. Double dies are used. The first one is a regular combination die, which cuts, draws and forms the blank. The press being in an inclined position, the work thus blanked slides by gravity down the chute, where it is caught and supported by a finger gage, which holds it in position beneath the second member of the die, which wires the edges on the next downward stroke of the ram. On this same stroke, of course, another blank is being cut and formed

Bliss Press arranged for Performing Two Successive Operations at Each Stroke.

in the first die. On the return of the ram to its upper position, the wired blank is released by the finger feed, and drops into a receptacle placed to receive it, after which the finger quickly returns to center the next blank, which has meantime dropped down from the first die. The feed is operated by the cam shown at the end of the crank-shaft. The ram has a stroke of two inches, and is operated by a crank-shaft made from hammered, high carbon steel. It is fitted with a cross-bar knock-out. The press, arranged as shown, weighs 5,350 pounds.

WILMARTH & MORMAN SURFACE GRINDER.

The builders of the tool shown in Figs. 1 to 4 call their machine a "surface grinder," but that title scarcely gives a proper idea of the range of operations which may be performed on the machine. If desired by the purchaser, it may be furnished for surface grinding pure and simple, but provision is made for using a cutter and reamer grinding attachment, or a drill grinding attachment when desired, so that, when completely fitted out, the machine will cover practically the whole range of tool-room work so far as concerns the sharpening of drills, cutters, reamers, dies, etc. The surface grinding table may be arranged to be operated entirely by hand, or may be supplied with automatic feed as desired. If supplied with automatic feed, this may be for the longitudinal movement only, or both longitudinal and cross movements may be automatic.

The spindle is of crucible steel, ground and lapped to size, and supported close up to the wheel, so as to do away with vibration due to springing and overhang. The spindle cone pulley is carefully turned both inside and out to secure per-

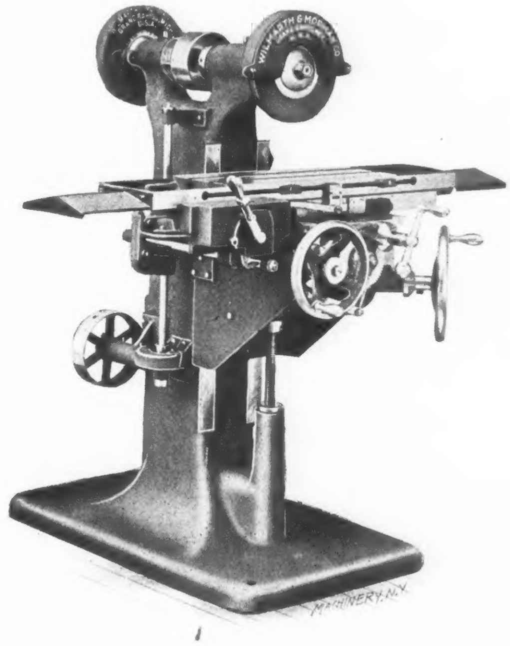


Fig. 1. Front View of the Wilmarth & Morman No. 2 Surface Grinder.

fect balance. The bearings are of phosphor bronze, with liberal dimensions, being 8 inches and 5 inches, respectively, in length, and tapering from 2 inches to $1\frac{1}{2}$ inch in diameter. The bearings in each box may be adjusted independently. The matter of lubrication has been carefully looked out for. The oil chambers are very large, and supply the bearings with oil through felt wicks, by capillary attraction. Surplus oil that may be run out to the front of the bearings is returned to the oil chambers by small channels. The bearings are carefully protected from dust and grit.

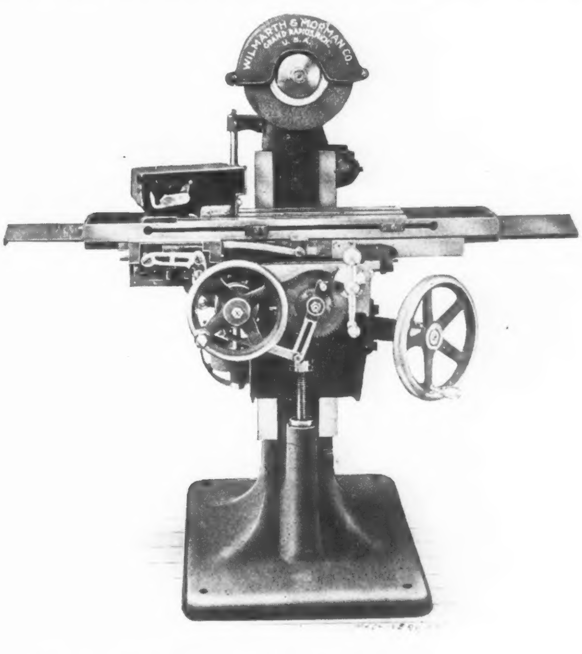


Fig. 2. Surface Grinder with Automatic Feed Box removed to show Mechanism.

The table of this machine is 8 inches wide and 50 inches long, and has a working surface of 8 inches by 20 inches. This 20 inches of length is carried by 36 inches length of saddle, so that the work is always well supported. A gib is attached to the rear of the table which effectually prevents any tipping, even when an excessive load is placed on the overhang end of the table at the extreme limit of its travel.

The machine is designed for a 10-inch diameter wheel for ordinary surfacing work, and with a wheel of this size, has a capacity for work up to 11½ inches high. The spindle driving cone has two steps, giving the proper speeds for both 7-inch and 10-inch wheels. The 7-inch wheel is used for cutter and reamer grinding, and may be used for surfacing as well, where circumstances make its use advisable.

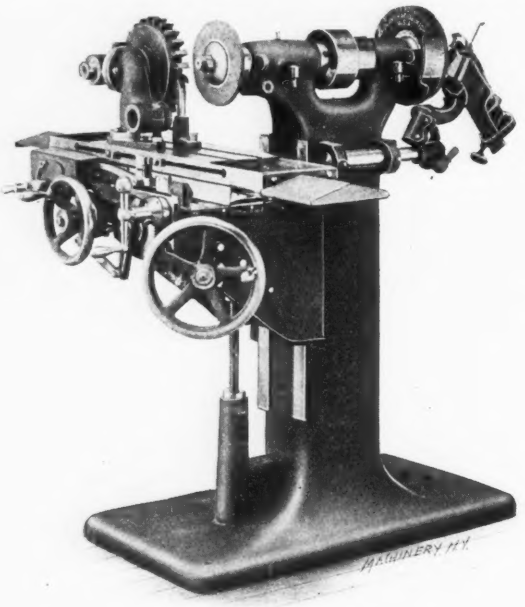


Fig. 3. Cutter Grinding Attachment in Use on Table of Surface Grinder. Note Drill Grinding Attachment on Rear of Column.

Where the machine is furnished for plain hand feed, the longitudinal movement is effected by means of the hand-wheel at the left of the front of the knee, and operates through a plain rack and pinion movement. The cross movement is by ball crank and screw, and may be read on a dial to a thousandth of an inch. The vertical adjustment is effected by a vertical screw running on a ball thrust bearing and working in a bronze nut. This adjustment may be easily read to half a thousandth of an inch.

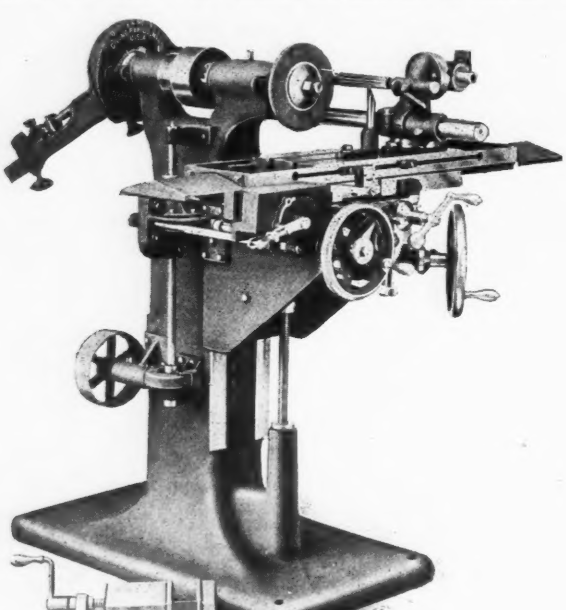


Fig. 4. Centers for Reamer Grinding in Use on Table of Surface Grinder.

When automatic feeds are used, as in the machine shown, the reversing mechanism is contained in a casing on the front left end of the saddle, shown removed in Fig. 2. The reversing lever may be placed in the center so as to hold the clutches in neutral position when desired, thus leaving the machine free for plain hand feeding. When the transverse feed is used, it is arranged to be applied or released by a friction clutch, operated by the knurled knob in the center of the table traverse hand-wheel. This feed may be arranged to act in either direction at the will of the operator, and may be varied in amount to suit the work in hand. All gears are carefully guarded, to protect them from dust, and from injuring the operator. The ways of the various slides are also protected from grit.

The cutter grinding attachment shown in use in Fig. 3, is universal in its application, and has a capacity for handling all kinds of milling cutters, including face and side mills up to 30 inches in diameter. It can be mounted on the table of the surface grinder by simply clamping it in place with two bolts, and can be manipulated as conveniently and quickly as regular cutter grinders made especially for the purpose. In Fig. 4 this cutter grinding attachment is shown in use in conjunction with centers, mounted on a bar and supporting a taper reamer for grinding. The adjustments of the attachment permit the grinding of reamers at any angle. Counterbores, end mills, etc., may be sharpened in the same way.

The "New Yankee" drill grinder shown attached to the rear of the column is a well-known tool. Its use on the same base does not interfere in any way with the use of the surface grinder, as one operator may be using the front side of the machine while another comes up and sharpens his drills, without either being in the slightest degree in the other's way.

NEW TYPES OF DRILLS AND CHUCKS MADE BY WHITMAN & BARNES.

The Whitman & Barnes Mfg. Co., of Akron, Ohio, and Chicago, Ill., has developed a line of drills to cover the requirements of the heaviest service that is asked of these tools in metal working. The first design, shown with the chuck for holding it, is illustrated in Fig. 1. As may be seen, this drill, known as the "Economy," is a modified flat drill. It is so made as to be capable of standing extremely heavy feeds in the very hardest and toughest materials, such as high carbon steels, hard cast iron, armor plate, steel rails, and steel castings. It is not especially adapted to work where unusual accuracy of diameter is required, nor should it be used for very deep drilling, it being best adapted for holes from 1 to 3 inches deep. The drills are made of the very best grade of high speed steel, are ground to size, and are tempered so that practically the whole length can be used. The chuck for holding them, as may be seen in Fig. 1, is so arranged that only as much of the drill as is necessary needs to project beyond the chuck. The back end of the drill fits a plug held in place by a cross bar secured by a retaining sleeve. In the body of the chuck are bored a series of holes in which the cross bar fits. By releasing the cross bar, the plug and drill may be moved out the required distance, the adjustment being fixed by slipping the retaining sleeve over the cross bar again. The use of this chuck reduces the torsional strain on the drill very

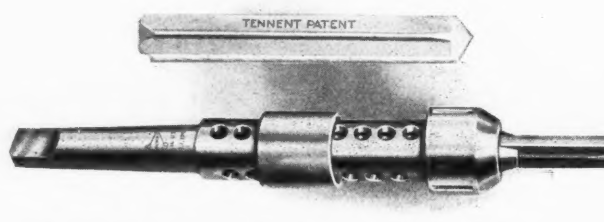


Fig. 1. The "Economy" Flat Drill and the Chuck for Holding it.

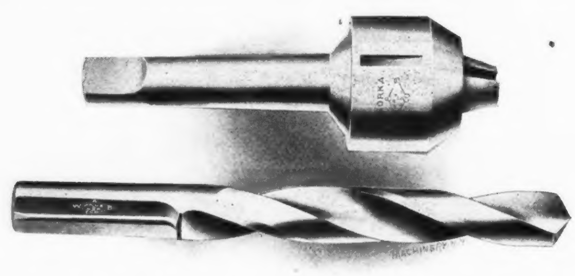


Fig. 2. The "Norka" High Speed Twist Drill and Chuck.

greatly, and increases its efficiency, so it may be run at a higher rate of speed without injury or breakage.

The "Norka" high speed twist drill and the chuck used for holding it are shown in Fig. 2. These drills are made from high speed steel, twisted while hot, so that the grain of the steel is not disturbed at all. This gives them great strength, ability to stand hard and rough service, and adaptability to all kinds of drilling in any class of material in which drilling is possible. They are ground to size, and proper clearance is formed on the flutes. In making the drill, the end of the blank is left flat and straight. This forms the shank, which fits into the chuck, so that there is no possibility of the tangs twisting off, or of the drills turning in the socket. This flat end of the drill is beaded to fit grooves in the jaws of the chuck, so that the drill is held firmly and centered. In the chuck used, the drill is centered by a steel plug, and is securely locked in the jaws with the clamping nut shown. The chuck may be used with taper shank drills by removing the jaws and steel plug, when the drill will fit into the chuck as in an ordinary sleeve or socket.

FRICTION-DRIVEN SENSITIVE DRILL PRESS OF NOVEL DESIGN.

The Washburn Shops of the Polytechnic Institute of Worcester are well known as being the only school or college shops actively engaged in the building of machine tools for the trade. Their drill grinders have been well known for many years. They have recently added to their line a new product, which we illustrate herewith; it is a friction-driven sensitive drill press, presenting novelties of design and construction which make it of unusual interest to the mechanic and designer.

As may be seen in Fig. 1, which shows the single spindle type, the tool has the convenient arrangement in which the head is vertically adjustable through a considerable range, and in which a circular table, vertically adjustable, is provided in addition to the usual swinging rectangular table. This combination is most useful, in that it makes provision for doing all sorts and conditions of work.

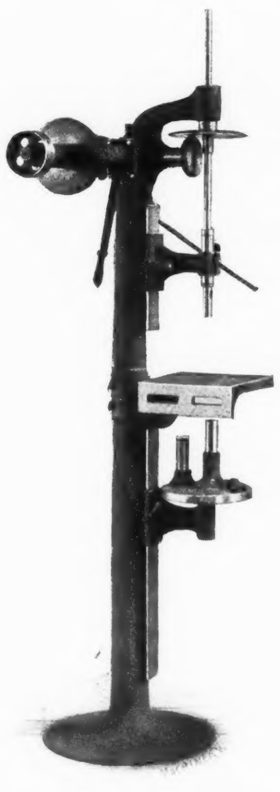


Fig. 1. Friction-driven Sensitive Drill Press, built by the Washburn Shops of the Worcester Polytechnic Institute.

In addition to the adjustments mentioned, the rectangular work table may be swiveled about a horizontal axis to present the work at any desired angle with the drill spindle. It is provided also with a short vertical face, with cored slots, by means of which the work may be clamped to it when it is more convenient to present it to the drill in this way. The round, vertically adjustable table may be removed, and either a V-center or a cone center used in its place. These are convenient for drilling cross holes in round work, or for center drilling round shafts.

The chief novelty of the arrangement, however, lies in the design of the friction drive provided. As may be seen, the machine is driven by a horizontal shaft at the back, carrying a friction disk which bears on the periphery of a fiber roll on a second horizontal shaft at right angles to it. The front end of this shaft carries a second similar fiber roll, bearing on the face of the disk on the vertical spindle of the machine. By means of the handle shown in Fig. 1 at the side of the column, this shaft and its two rolls can be moved toward the rear or toward the front, thus changing their positions on the faces of the disks, and decreasing or increasing the spindle speed in a total ratio of about 4 to 1, for an end-wise movement of only about 2 inches.

The most original feature of this arrangement is the provision made for supplying just enough pressure to the friction drive to transmit the required amount of power. As is best

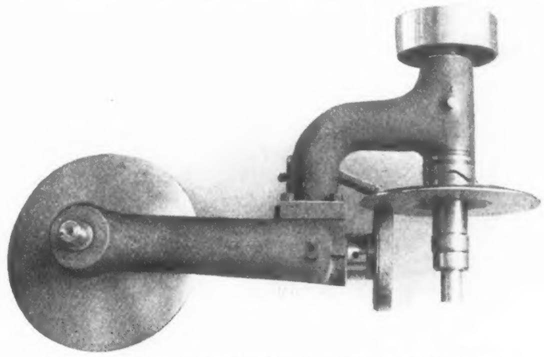


Fig. 2. Top View of Machine, showing Friction Drive.

seen by comparing Fig. 1 and Fig. 2, both of the friction disks are loose on their shafts, being driven from them by cam faces on their hubs, corresponding with and bearing on cam faces on collars fast to the shafts. When no resistance is offered by the drill, very little power is required to rotate the spindle. Under these circumstances the disks are only lightly in contact with the rollers. As soon, however, as the drill reaches the work, the contact between the friction disks and their rolls is not enough to drive the spindle. Under these circumstances the friction disks slip on the shafts, but this slippage involves the climbing of the cam surfaces of the disks and their collars on each other in such a way as to force the friction parts into closer contact. Every bit of slip, therefore, involves an increased pressure on the friction rolls, so that this pressure is always great enough to drive the spindle, but is never any more than is needed.

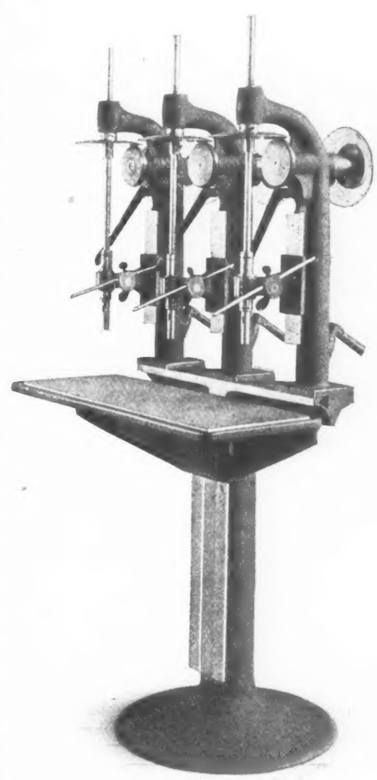


Fig. 3. Multiple Spindle Form of the Machine, with the Columns Adjustable for Center Distance.

This arrangement makes unnecessary the use of cones and quarter-turn belts, and permits an instantaneous change of speed. The thrust of the friction members is taken up by ball bearings, and the journals of the two horizontal shafts are ring-oiled from ample oil reservoirs. No counter-shaft is required. To stop the spindle, the speed lever is thrown to its extreme position. While in this position, the driven roll is out of contact with the driving disk, which is recessed for this purpose to clear the roll.

The elimination of this counter-shaft is especially advantageous in the multiple spindle type of machine, shown in Fig. 3. Note the ease with which the variations of spindle speeds may be obtained without the trouble of shifting belts. This design also presents a much neater appearance than is possible in designs which depend on a quarter-turn belt to transmit the power. Each head of the multiple spindle type is a unit in itself, and the heads may be slipped along the bed to any position required, to drill to within a minimum center distance, between adjacent drills, of 10 inches. Any head may be taken from the base, or extra heads may be

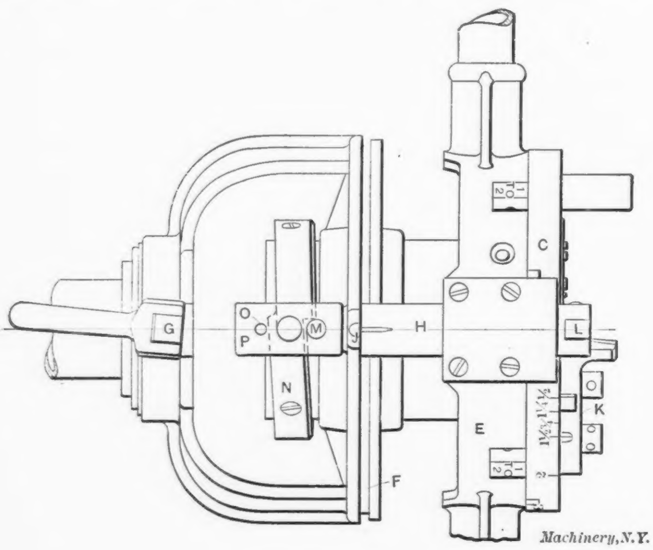
added, as the work requires. The head is fastened to the base by a T-bolt set at an angle, and is brought down and forward into position by the lever and nut shown at the rear of the machine.

The spindles of these machines have a feed of 3 inches, and a vertical adjustment of 7½ inches. The diameter of the spindle in the sleeve is ⅞ inch. The single spindle machine weighs about 250 pounds, the two-spindle 450 pounds, and the three-spindle, 650.

This machine is not an experiment, having been thoroughly tested for several months by everyday use in the Washburn Shops. It is designed for sensitive drill work, and will handle both carbon and high speed steel drills up to 9/16 inch in diameter, at their proper speeds and feeds.

HART'S "BUCKEYE" DIE-STOCK.

The accompanying line-cut, Fig. 1, and the half-tones, Figs. 2 and 3, illustrate an interesting die-stock for threading pipe, manufactured by the Hart Manufacturing Co., 10 Wood St., Cleveland, Ohio. The principal feature of this die stock is that the chasers which cut the tapered thread, and which are inserted into the die body, are not as wide as the length of the thread, but the mechanism permits the chasers to recede from the work as the thread progresses along the pipe, so that a full length thread is cut on the pipe by this means. This construction permits the use of chasers with comparatively narrow faces, and this, in turn, reduces the amount of power necessary for turning the die-stock, which is explained mostly by the reduction of friction between the chasers and the metal being cut, which is considerably less than the friction in the case of dies which have chasers of usual length of face, equal to the length of the taper thread required.



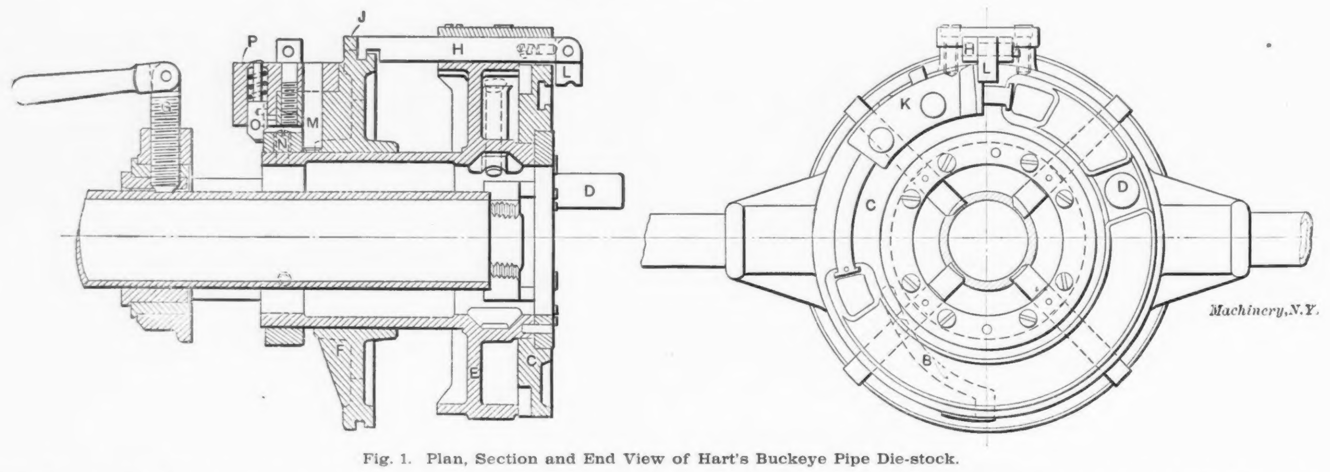


Fig. 1. Plan, Section and End View of Hart's Buckeye Pipe Die-stock.

Another of the principal features of the die is that as soon as the full length of the tapered thread has been cut on the pipe, the chasers release automatically, and as soon as a slight turn by hand of the cam which controls the radial position of the chasers has been made, the chasers will clear the threads which have been cut, and the die can be removed directly by pulling it outward without turning it backward over the threads. The dies can be instantly reset to the proper position for cutting the thread on another pipe of the same size by simply turning the cam plate back to the original position, no clamping of any kind being necessary.

A third feature wherein this die differs from the ordinary die-stocks for pipe threading is in the adjustment of the dies. A wide range of sizes may be cut with the same chasers by simply loosening a screw and setting a stop to the required graduation, the chasers thereby being pulled out or pushed in, by means of cam grooves, to the position required for cutting the corresponding sizes of pipe.

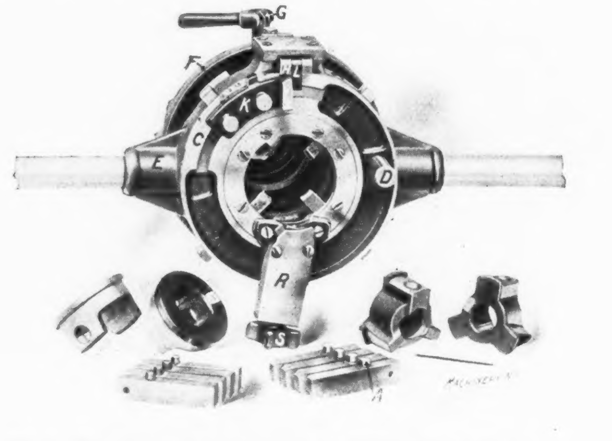


Fig. 2. Front View of the Buckeye Die-stock, showing Cam Plate, Adjusting Dog and Stop, and Cut-off Attachment.

Instead of the leader screw ordinarily used in dies of this type, a so-called leader ring has been adopted, which, as will be presently explained, feeds the die inward over the pipe for the first revolution of the die-stock, thus causing the chasers to start the thread without any hand pressure or extra exertion. The same leader ring is employed for different pitches. Theoretically, of course, it might be claimed that the rise of the cam surface of the leader ring, which causes the feeding-in motion of the die, should be exactly the same as the pitch of the thread, so that a different leader ring would be required for each different number of threads per inch, but as this leader ring simply serves the purpose of starting the thread, the slight difference in rise between the cam surface on the leader ring and the pitch of the thread is of no practical consequence.

A description of the design of the die will show how these various features are accomplished by the mechanism employed. In Fig. 2 is shown a full set of chasers. On the top surface of these chasers a small pin *A* will be noticed. The pin works in an eccentric groove *B* shown in the end view in Fig. 1, this groove being cut in the cam plate *C*. Thus, when this cam plate is turned, the cutting edges of the chasers evidently approach toward, or recede from, the center of the die. A handle *D* is provided for this cam plate, by means of which it can be turned by hand. It will also be seen from Fig. 1 that the die consists, in general, of a revolving part or body *E*, in

which the chasers are inserted, and a stationary part F, called the frame. The actual design of this frame is most clearly shown in Fig. 3. When wanting to thread the pipe, the body E is first placed in the correct position in relation to the frame F, by turning it so that the bar H comes exactly opposite to the indicating boss J on the frame. The body E is also pulled forward out of the frame F as far as possible. The dog K is now placed, and tightened to the cam plate C,

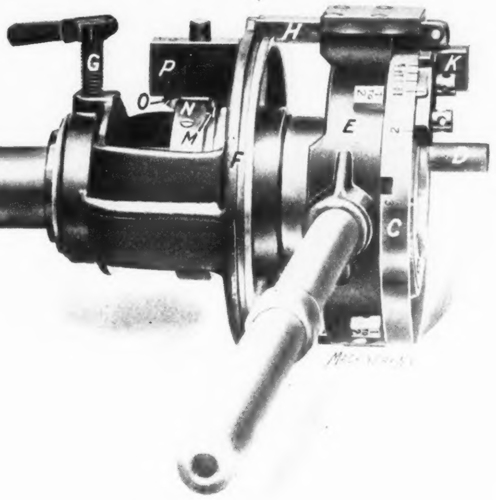


Fig. 3. Side View of Pipe Die-stock, showing Frame, Leader Ring and Graduations on Side of Cam Plate.

in such a position that the indicating mark on the dog coincides with that graduation on the cam plate which corresponds to the size of the pipe to be threaded. This is most clearly shown in Fig. 3. After having clamped the dog K as mentioned, the cam plate C is turned by means of handle D until the face of the dog K touches the side of the stop L. The chasers are now in the proper position to start cutting the size of pipe for which the dog K has been set. The die is placed on the pipe, the bar H being over the center of the pipe, and the pipe is permitted to enter into the die as far as possible, after which the binding screw G is clamped, thereby holding the frame F of the die firmly to the pipe.

The die body E, with the chasers, is now turned, as in ordinary threading. During the first turn the pin M, which is stationary, feeds the body E inward by acting against the cam surface of the leader ring N, which is held to body E by three set-screws. As soon as the die has been turned once, the chasers themselves have gripped the pipe enough to feed the die forward. As this forward motion proceeds, the body E progresses closer toward the frame F, and the bar H, which is held at one end in a groove in the frame F, is pushed forward out through the body E, the distance between the stop L and the face of the cam C, of course, then becoming greater. The face of the stop L and also of the dog K, where they bear against each other, is formed according to such a curve that the plate C will move slightly in a clock-wise direction as the stop moves outward, and by this motion the chasers are withdrawn the proper amount from the center of the die to form the correct taper of the thread. The pressure of the threading operation on the chasers is utilized for effecting the turning of the cam plate, so that the dog K always bears against the stop L. As soon as the thread is fully completed, the stop L slides completely by the dog K, thereby leaving it free to move any amount in a direction toward the right. The cam plate is then turned by the handle D a sufficient amount to the right to release the chasers completely from the thread, and the die is removed from the work by simply pulling it outward, there being no need of turning the die backward. In fact, it should not be attempted to turn the tool backward over the threads, as that might result in injury to the threads.

It will be noticed that a plunger O is located against one side of the leader ring N. This plunger simply serves the purpose of locating the leader ring N against the pin M, at the beginning of the cut. When the body E has almost completed one revolution, the plunger O mounts on an incline, on the rear edge of the leader ring N, and disengages this edge, thereby permitting the body E, with the leader ring, to progress independently of the frame F which holds the bracket in which the pins O and M are mounted. It will also be noted by examining the plan view of the die in Fig. 1 that, at the beginning of the cut, when the pin M is placed in relation to the leader ring N as shown, it is possible to turn the body E only in the right direction for the thread to be cut, the pin M bearing against a shoulder on the leader ring in the other direction, thus preventing turning the die-stock the wrong way.

When left-hand threads are cut, the plunger block P may simply be removed and the operation of threading proceeds in the same way as when cutting right-hand threads, excepting that hand pressure is required to force the chasers to grip the pipe. A left-hand leader ring N, however, is supplied with these dies if required.

Straight threads may be cut by not clamping the binding screw G, thus permitting the frame F to revolve freely on the pipe, together with the body E.

The die-stock is also equipped with a cutting-off attachment, as shown at R, Fig. 2. The cutting-off tool in this attachment is fed inward by the knob S, while the die-stock is turned around in the same way as when cutting threads. Back rests shaped in the same way as the chasers, but having blank end surfaces, support the die on the pipe during the cutting-off operation.

THE POTTER & JOHNSTON LONG TRAVEL CHUCKING MACHINE.

The use of cams in one form or another has been found to be the most practical method of controlling the movements of automatic turret machines of all kinds. There is no limit to the complexity of motion it is possible to obtain from them. The working parts may be advanced, stopped, withdrawn, and advanced again at any rate of speed and for any length of travel desired. Effecting these same movements by the use of the rack and pinion, or a screw and nut, operated by gearing and controlled by clutches, would be a matter requiring mechanism so complicated as to be impracticable.

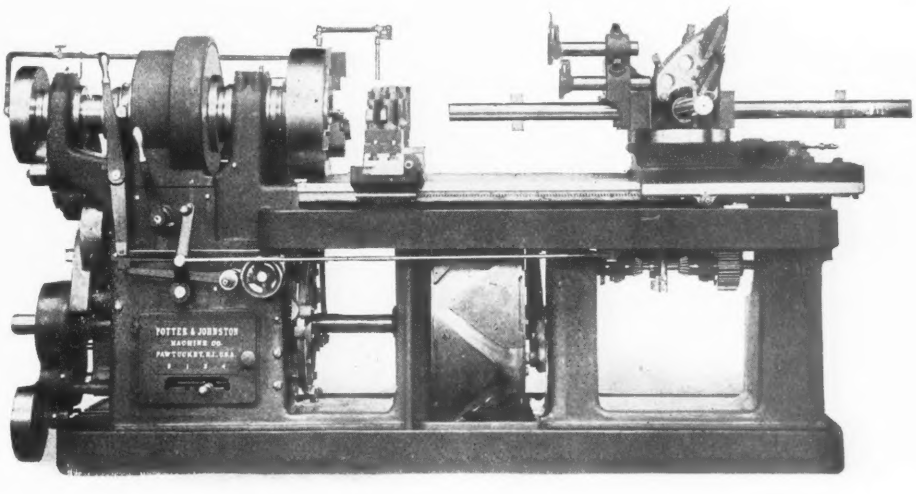


Fig. 1. Potter & Johnston Chucking Machine, with "Long Travel" Mechanism, allowing the Use of Long Pilots, Boring-bars, etc.

There is one difficulty, however, with the use of cams for large machines, which is well shown in the case of the automatic chucking machine built by Potter & Johnston, Pawtucket, R. I. This difficulty is the great size of the cam required for movements on large machines. As may be seen by referring to Fig. 1 in the article describing

the operation of this machine (a few pages back in this same issue of MACHINERY), the turret cam drum is made of as large diameter as is possible, filling practically the whole space available between the turret slide and the floor. For the range of work for which the machine is intended, this gives sufficiently easy rises for the cam, and operates the mechanism very satisfactorily.

When it comes, however, to controlling the movements for operations requiring very long travel, the diameter of the

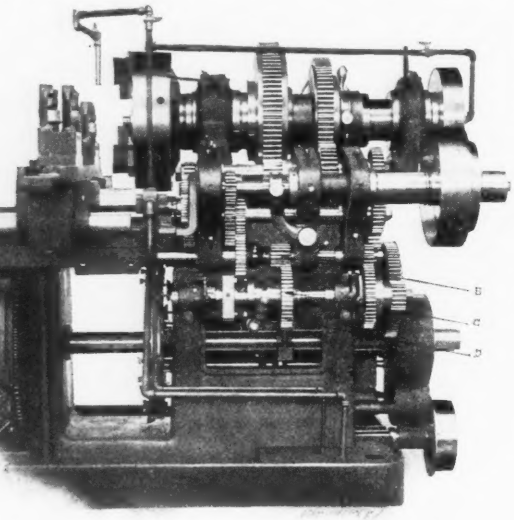


Fig. 2. Geared Connections for Effecting all the Idle Movements at Constant Speed.

drum would have to be so greatly increased to allow the use of the same easy rises for the cams, that it would be entirely impossible to incorporate it in the machine. This difficulty is especially met with in providing for the necessary movements for handling tools carrying pilot bars, which bear in a bushing in the nose of the spindle and are used to steady the tools under the pressure of the cut. These long bars require that the turret slide be moved back a long distance to enable them to clear the work for indexing. They then have to be brought up for a considerable distance again before the tools are ready to cut. This long travel it is impossible to effect by cams, as we have shown. The difficulty has, however, been overcome in another way by the builders, and they have succeeded in building a combination of rack and pinion, and cam operated mechanism which gives the flexibility of the cam mechanism, and the long travel of the rack and pinion device, without requiring the cam drum to be increased in diameter, or involving the complexity usually attendant on the use of the rack and pinion. The machine, as a whole, will not be described, the readers being referred to the article previously mentioned for a more complete treatment; only the difference between the "long travel" and the standard types of machine will be touched on.

The turret slide is under the influence of the cams for the feeding movements, and for returning the turret slide again to the point where the feeding movement commences. When it has been returned to this point, however, a clutch is automatically thrown in which starts the rotation of a pinion geared with the rack connected with the turret slide, so that the latter is rapidly drawn backward as far as may be required for clearing the work with pilot bars, such as those shown in place in Figs. 1 and 3. Here the turret slide stops, the indexing mechanism is thrown into action and the turret is revolved. When this has been accomplished the pinion is again rotated, but in the opposite direction, and by its action on the rack the turret slide is moved forward until the cam roll is again in position to be acted on by the cams for feeding.

This is repeated for each operation of the turret, the front portion of the travel of the slide being taken care of by cams, while the backward end of the movement is effected by the rack and pinion controlled by clutches and reversing movements. These two mechanisms are made so dependent on each other that they work together automatically without requiring any attention or adjustment on the part of the operator at any time, their relations being permanently fixed in the design of the machine. The long travel mechanism may, however, be thrown out of use by shifting to the proper position, a lever shown at the back of the machine in Fig. 3. The long travel mechanism is operated by the same shaft that controls the indexing. There is no limit to the length of bed which may be used with this device. It may be extended as far as necessary to clear the longest tools that the machine may ever be called on to use.

Another important change has been made in the design of this machine, as compared with the previous standard type of automatic chucking machine. In this machine the fast movement of the cam shaft has been arranged (as may be seen in Fig. 2, which shows the rear view of the tool with the guards removed) to be driven by the constant speed pulley, while the slow or fast feed movement is connected directly with the spindle, as before, so that the feed in turns per minute remains constant for a given combination of gearing, whatever the spindle speed. But by this arrangement the fast movements take place always at the highest practicable speed, whatever the spindle speeds may be. The same is true, of course, of the indexing and long travel movements, which are also connected with the constant speed pulley.

In Fig. 2, *B* is a loose double gear connected to the driving pulley, and running at constant speed, driving the gear *C*. When clutch *D* is thrown in by the action of the star-wheel which controls the feed mechanism, a fixed constant speed is transmitted to the drum operating gearing, which is thus moved rapidly, running ahead of the slow feeding motion.

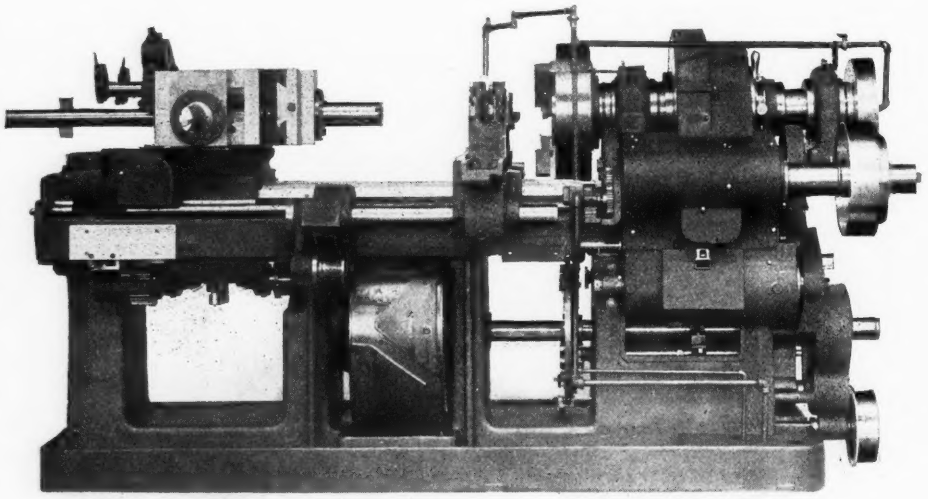


Fig. 3. Rear View of the "Long Travel" Automatic Chucking Machine.

This slow feeding motion again becomes operative as soon as clutch *D* is thrown out. As in the older style of machine, the feeding movement is driven by a belt running from the pulley at the rear end of the spindle to the feed pulley at the base of the machine.

A number of improvements have been made in the general design as well. The ways and slides have been made very wide and substantial throughout, and the turret and its supporting base have been enlarged. While the same principle has been maintained in the turret revolving mechanism of this machine, as in the standard design, a change has been made in the method of operation. When this slide reaches its extreme backward position, it stops for a few seconds while the turret revolves, so that all of the distance possible between the chuck and the end of the bar is gained.

None of the slide movements take place while the rotating is in action. The arrangement is such that with even heavy tools like those shown in Figs. 1 and 3 working on large diameters, the turret revolves very gently and comes to its position without any shock or jar.

The tool equipments shown in Figs. 1 and 3 are interesting, and may be studied in connection with the article on the setting up and operation of the machine. In Fig. 1, long boring bars with pilots entering the supporting bushing in the chuck, are used in combination with standard turning tools, bolted to the faces of the turret. In Fig. 3 one of the faces is provided with this combination of boring-bar and standard facing tool. The other two faces have boring-bars mounted on supplementary cross slides bolted to the table and actuated by the main cross slide. These are used for recessing, etc.

The advantages of this long travel mechanism will be easily understood. Without complicating at all the setting up of the machine (which is in itself a simple matter), it permits the use of tools provided with long pilot bars which, by the support they give to the cutting tools, allow heavier chips to be taken and produce work of very much greater accuracy. It will thus be seen that the arrangement is an important improvement of an already useful machine.

HAHN FLEXIBLE SHAFT.

The flexible shaft shown herewith is made by William Hahn, 220 Washington St., Chicago, Ill. In the sample illustrated, the shaft is covered with a thick braided cover and provided with end couplings of the kind generally used for dental work. It is made in larger sizes, however, for operating grinding

Hahn Flexible Shaft made of Coiled Piano Wire.

wheels, portable drills and other such tools where flexibility of drive is an important factor in the usefulness of the device. This shaft is built up of multiple coiled springs, both right-hand and left-hand, so that it may be run in either direction. These coils are formed of piano wire, and the device is thus as strong and durable as it is possible to make it.

ATTACHMENTS TO THE HAMILTON LATHES FOR TAPER TURNING AND RELIEVING.

Two new attachments of unusual interest have been recently designed by the Hamilton Machine Tool Co., of Hamilton, O., for its line of Hamilton lathes. The first one, shown in Fig. 1, is a taper turning attachment. This attachment is fastened to the carriage, and is always in position to use, the design being such that it can be added to a lathe which has been properly drilled and tapped to receive it, whenever the owner desires to purchase the device. As may be seen, the carriage has fastened to it a bracket, provided with a slide, which is connected by a rod with a clamping bracket, which latter may be fastened to the bed at any desired point. This slide carries a swiveling guide bar, which is adjusted to the degree of taper wanted by the adjusting screw shown, suitable graduations being furnished to facilitate the setting. This swivel slide bar carries, on dove-tailed ways, a sliding shoe, which is pivoted to a connecting bar, in which is journaled the rear end of the cross feed screw. The attachment is never disengaged. To change from straight

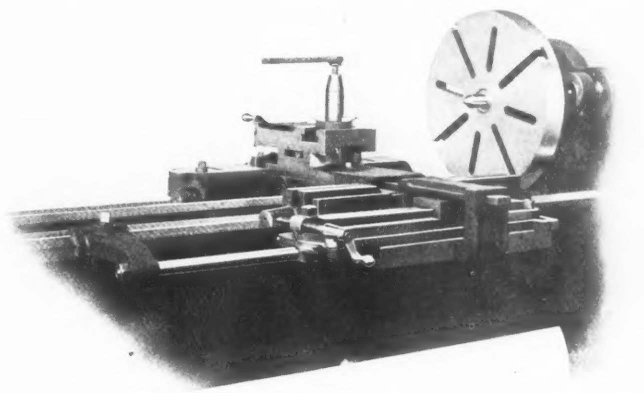


Fig. 1. Taper Attachment for Hamilton Lathes.

to taper work it is only necessary to tighten the bolt in the clamping bracket and set the guide bar to the desired taper, as shown by the graduated scale. To disconnect the taper attachment, the bolt in the clamping bracket is loosened. The tool-post wrench fits all the bolts used for adjusting the taper attachment.

The relieving attachment shown in Fig. 2 is used for backing off the teeth of milling cutters, taps, hobs, and similar tools. It is remarkably flexible in its applications, it being possible to use the attachments with the screw-cutting mechanism and the taper attachment, the relieving action taking place at any angle. This last feature, which is patented, is accomplished by having the reciprocating action necessary for the backing off, act through the center of the compound rest, so that it is effective at any angle through a full circle, not being limited by universal joints, etc., which are effective only through a limited angle. This makes the device universal in relieving formed end mills, counter-bores, etc., where the tool has to work at right angles to the cross slide movement.

The construction is quite simple, the cam being mounted on the carriage or compound rest, while the driving gearing,

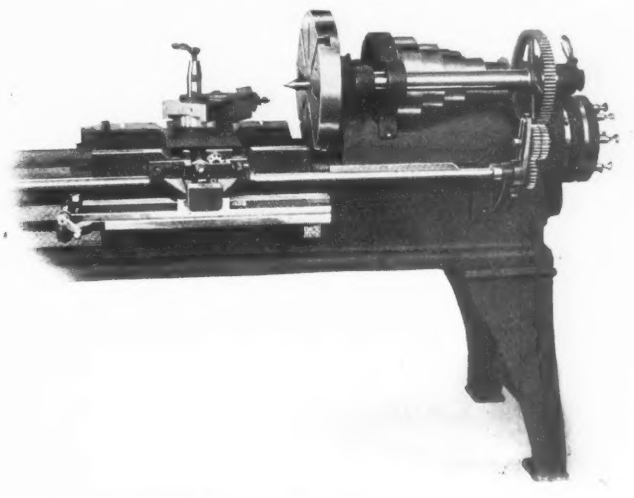


Fig. 2. Relieving Attachment for Hamilton Lathes, which works at any Angle.

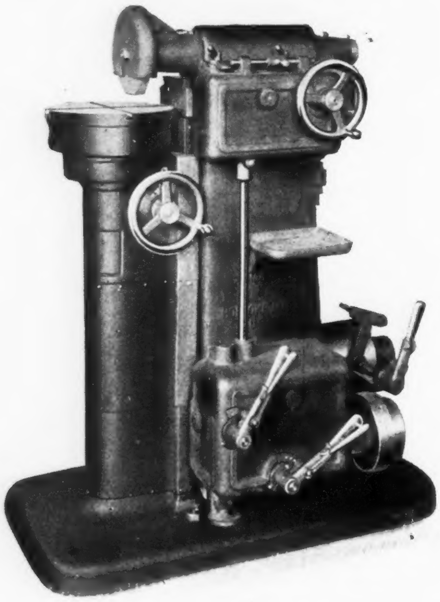
shaft, etc., is attached to the back of the bed. The driving change gears are placed on an adjustable bracket, which can be quickly removed when it is desired to leave the lathe free for regular work. The relieving cam is driven from the large back gear, which is the most suitable arrangement for such work, as it is thus possible to speed the relieving cam up at the proper rate in relation to the work, without strain-

ing any part of the mechanism. The back gears are, of course, naturally used in giving the slow movement required for relieving operations.

This attachment is furnished by the builders only for their 16-inch lathe, this being the size best adapted to general tool-room use. Change gears are provided for relieving cutters having from 2 to 24 teeth. Cams are regularly furnished, giving clearance of 1/32, 1/16 and 3/32 inch, respectively. Two styles of the device are furnished, in one of which provision is made only for the usual relieving movement at right angles to the axis of the lathe. The universal relieving attachment is the same as the plain, with the addition of the necessary parts to provide for relieving at any angle at which the compound rest may be set. These attachments must be ordered at the same time as the lathe they are used on, as a special carriage and tool rest has to be used.

IMPROVED SAXON RING GRINDER.

The accompanying half-tone illustrates a new ring grinder, which has been brought out by the Saxon Machine Co., Holyoke, Mass. The design of this grinder is very simple, and it



Improved Ring Grinding Machine made by the Saxon Machine Co.

can be operated easily by inexperienced help. Care has been taken to place all handles and dogs for adjusting the grinder, on the side nearest to the operator. The machine is driven directly from the main line, a special counter-shaft not being necessary. An important feature in the machine is its weight and stiffness, special attention having been paid to the matter of rigidity, when designing this machine.

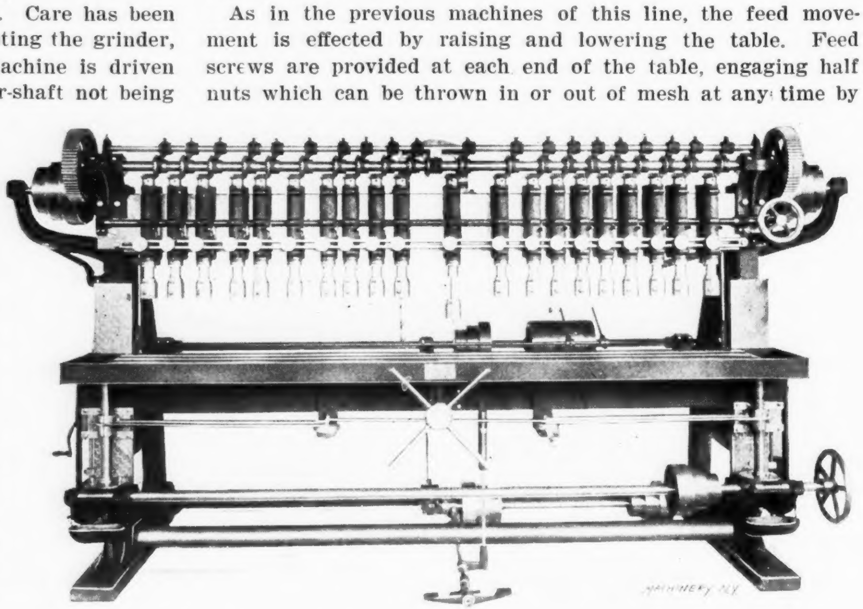
The work-holding chuck is attached to a vertical spindle, driven from the lower gear box. This gear box gives 8 different speeds for work of varying diameters. A magnetic chuck is regularly fitted to each machine, as this affords the quickest way of fastening the work for grinding and eliminates the liability of springing the work, which is always present in greater or less degree when the work is clamped by mechanical means. The magnetic chucks are furnished in three different sizes, having 8⅝, 10⅝, and 12¾ inches diameter. A direct current of either 110 or 220 volts may be employed for supplying electricity to the chuck, and connection can be made directly to a lamp socket. In cases where direct current is not available, the makers of the grinder furnish a small generator which can be placed in any convenient place around the shop, and wires brought to the grinder. The amount of current required by the chuck when in operation is no more than that required by an ordinary incandescent lamp. A plain chuck is furnished for brass, copper, hard rubber and other materials, which cannot be held by magnetism, or for use in cases when the magnetic chuck is not wanted. This plain chuck is furnished with three or four jaws as required.

The wheel-carrying head may be adjusted in such a manner that the work may be ground thicker or thinner at the center than at the circumference. The necessity for such adjustment, as is well known, is present when it is required to grind slitting saws and plain cutters, having no teeth on the sides, but intended for cutting slots or grooves in the work. This head is provided with three speeds. The feed is automatic, but can be operated by hand when necessary. The spindle carrying the grinding wheel is provided with adjustable bushing bearings, thoroughly protected by caps from dust. The use of bearings of this kind permits the best means for taking up the wear. The height of the center of the spindle from the floor line is 46 inches. The greatest distance from the center of the wheel to the chuck is 12 inches, and the size of the grinding wheel is 8 inches diameter by ¾ inch width of face. The speed of the driving shaft is 450 R. P. M. The floor space required for the machine is 26 x 45 inches, and the net weight about 1,300 pounds.

ANDREW IMPROVED MULTIPLE DRILLING MACHINE.

In the November, 1907, issue of MACHINERY, a multiple drilling machine intended for heavy duty, built by M. L. Andrew & Co., 2852-2854 Spring Grove Avenue, Cincinnati, Ohio, was described and illustrated. The accompanying half-tone shows an important improvement introduced on these machines for the purpose of rapid and accurate adjustment of the position of the spindles along the cross rail. This adjustment is accomplished by turning the hand-wheel at the right-hand side of the machine, from which the long adjusting screw receives its motion. Each of the spindle-carrying heads is provided with independent means for connecting them with this screw, they being engaged and disengaged by suitable handles. A slotted bar runs in front of the machine, as shown, and the various heads, when adjusted, are clamped to this bar by knurled nuts. Two men are, of course, necessary to carry out the adjustment, one turning the hand-wheel and with it the adjusting screw, while the other operates the handles, engaging and disengaging each head with the screw until the proper position for each spindle has been obtained. This feature is distinctly new, and will prove a great convenience in adjusting the spindles.

As in the previous machines of this line, the feed movement is effected by raising and lowering the table. Feed screws are provided at each end of the table, engaging half nuts which can be thrown in or out of mesh at any time by a lever conveniently located for the operator. The table, being counterbalanced with adjustable weights, may be easily raised or lowered by operating the pilot wheel at the front. Each spindle has an independent vertical adjustment of 4 inches, to make allowance for the various thicknesses of work



Andrew 20-spindle Multiple Drilling Machine, with Improved Method of Adjusting the Spindle.

and various lengths of drills. The spindle driving gears are made of high carbon steel, accurately cut so as to be nearly noiseless in operation. The main driving gears are driven by rawhide pinions, keyed to the cone pulleys. The table has sufficient feed and the drive is sufficiently powerful to drill twenty ⅞-inch holes in steel, 8 inches deep, at one time. Larger or smaller machines of this description can be furnished, according to the capacity required.

CHICAGO BORING TOOL HOLDER.

The Krieger Tool & Mfg. Co., of Grand Rapids, Wis. (main office 479 North Park St., Chicago), is making the boring tool holder shown in Figs. 1 and 2. As may be seen, this holder is adapted to a wide range of sizes of boring tool shanks, owing to the peculiar construction of the clamp, which is made

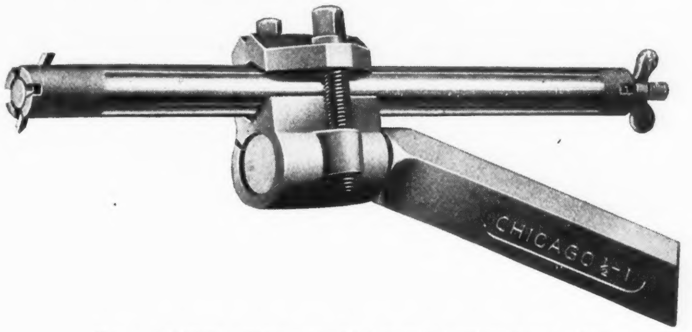


Fig. 1. Chicago Boring Tool Holder with Boring-bar in Place.

with a large V on one side for tools such as shown in Fig. 1, and a smaller V on the other, so that it will hold very small diameters when reversed, as shown in Fig. 2. The full range of diameters is for shanks from ⅛ up to ¾ inch, no blocking being required.

In Fig. 1 a boring-bar is used with an inserted tool. Boring tools of different sizes, such as shown in use in Fig. 2, will also be provided as a part of the outfit. The head can be swiveled about a pivot on the shank, so as to bring the tool

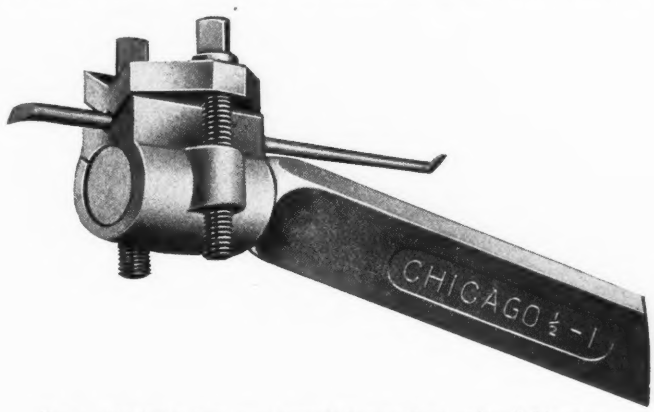


Fig. 2. Holder in Use with Forged Boring Tool of Small Diameter.

to the desired height to center with the axis of the lathe. The boring tools, and blades for the boring-bar, can be furnished in high speed steel or carbon. The steel holding parts are drop forged and case-hardened. The tool may be used for holding inside and outside test indicators, as well as for boring.

IMPROVED MELVIN ADJUSTABLE BORING HEAD.

We have previously described the boring heads made by Melvin & Hamaker, of Meadville, Pa. (see New Machinery and Tools in the November, 1907, issue of MACHINERY). The boring head shown in the cut, made by the same builders, is of larger size than the one previously shown, and includes some new improvements in design. The front collar or clamping ring is provided with graduations, which enable the operator to get the required changes without measurement. An intermediate is provided, having rubber rings, which maintain the pressure on the cutters even when the front collar is loosened. This serves two purposes: First, it prevents the cutters from falling out, or loosening so as to allow chips to accumulate between the cutters and their seats; and second, it allows the operator to make adjustments without the liability of disturbing the seating of the cutters in the grooves which hold them. The blades, as was explained in the previous description, are formed from steel having an equilateral triangular section, and are seated in grooves

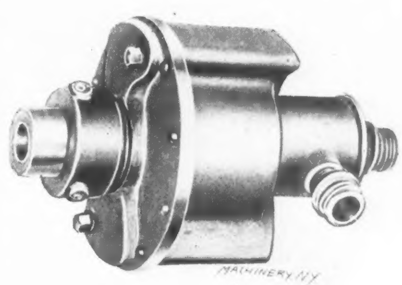
Adjustable Shell Type Boring Head, made by Melvin & Hamaker.

of corresponding shape in the body of the tool, which present them to the work at the required cutting angle. When one cutting edge is dull, the blade may be turned in its seat, presenting a new one. By doing this, six new cutting edges may be obtained in succession. When the point of the tool is rounded to give a smooth finishing cut, four cutting edges are provided for.

These shell type heads are made in all sizes, from 5 inches to 18 inches in diameter. They have an adjustment of from ⅜ to 1 inch in diameter, depending on the size, this adjustment not being provided for on sizes less than six inches.

COFFIELD WATER MOTOR.

The engraving shown herewith illustrates a water motor of the positive piston type, invented by Mr. P. T. Coffield, of Dayton, Ohio, and sold by the Patterson Tool and Supply Co. of the same city. This differs from the ordinary water motor in the fact that the direct pressure of the fluid is utilized on a steel piston, instead of employing the kinetic energy of the fluid, impinging against the floats of a rotating wheel. Numerous advantages result from this arrangement. It is stated that higher power is developed than with jet motors with the same water consumption. The device may be operated at slow speed or at high, often making reduction gearing or countershaft unnecessary. Another important feature is the fact that the exhaust of the water from the motor does not have to be so arranged as to preclude the possibility of back pressure. On the contrary, the exhaust can be piped away for any desired distance, and used for any purpose desired, the back pressure merely serving to reduce somewhat the power instead of entirely stopping the action of the device as in the case of the jet machine.



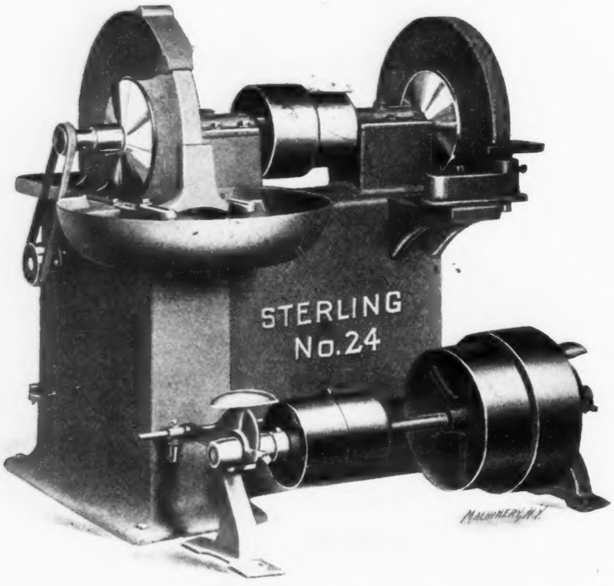
A Positive Piston-action Water Motor.

The motor is simple in construction, having only two valves and a piston. These parts are leather-packed in such a manner that leakage is reduced to a minimum. The machine shown, running at a speed of 100 revolutions per minute, developed 1/10 of a horse-power, with a consumption of water of

1 1/3 gallon per minute—at what pressure the report does not state. An efficiency of 100 per cent would require a pressure of about 110 pounds per square inch, under the conditions given.

STERLING COMBINATION WET AND DRY GRINDER.

The grinder shown in the accompanying engraving has been designed by its builder, the Sterling Emery Wheel Mfg. Co., Tiffin, Ohio, to combine the advantages of the wet tool grinder and the grinder for general purposes in one machine, thus economizing floor space. The water bowl and hood are detachable. The tool grinding section has no pump, but is



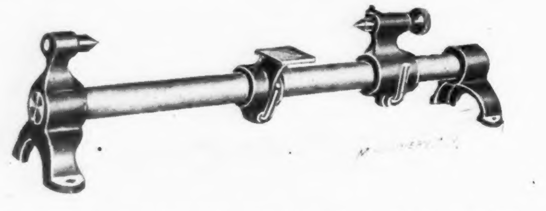
Sterling Combination Wet and Dry Grinder.

equipped with a revolving disk which throws a supply of water on the wheel when running. The tool grinding wheel is 24 inches in diameter by 3 inches wide; the dry wheel is of the same diameter, but 4 inches wide.

The weight of the machine, with the counter-shaft, is 1,800 pounds.

WELLS BENCH CENTERS.

The engraving we show herewith illustrates a new bench center built by the F. E. Wells & Son Co., of Greenfield, Mass. These bench centers are strong and inexpensive, and in many cases they take the place of the lathe in testing work to see if it runs true on the center. The tail-center is pressed outward by a coiled spring, so that it holds the work securely,

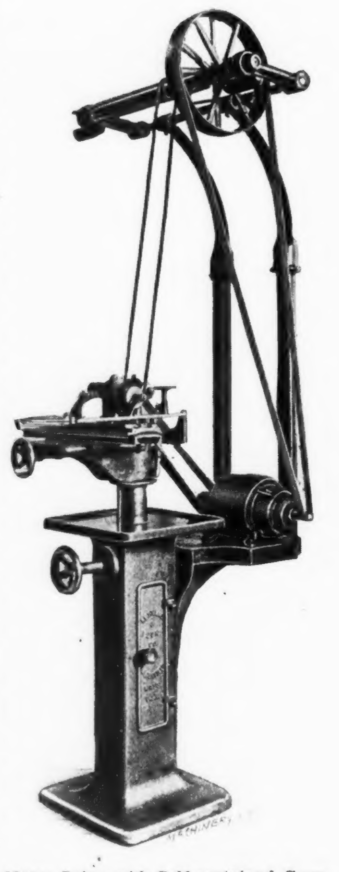


Inexpensive Bench Centers, taking the Place of the Lathe for Balancing Shafting, etc.

while still allowing it to revolve freely. This arrangement also permits the work to be inserted and removed quickly. This center may be adjusted along the bar to suit different lengths of work. A test indicator may be furnished in connection with this center-rest, if it is desired to show how much the work is running out at any point.

MOTOR DRIVE ARRANGEMENT FOR WELLS GRINDER.

F. E. Wells & Son Co., of Greenfield, Mass., has provided a motor drive on its cutter and reamer grinder, arranged as shown in the accompanying half-tone. As may be seen, the motor is mounted on a bracket, clamped to the rear of the column, and is directly belted to the emery wheel spindle. The work spindle, which is given a longitudinal movement in the operation of the machine, is driven from a drum on the overhead counter-shaft, which is supported from the motor bracket, and belted to the outer end of the armature shaft, as may be clearly seen from the engraving. An idler, which does not show in the cut, is provided, by means of which the work driving belt tension is kept the same, regardless of the adjustment of the cross slide on which the work belt is mounted.



Motor Drive with Self-contained Counter-shaft for Wells Grinder.

The motor is so placed that the table can be swung to present the work at any angle to the wheel, without interference with the belts or upright standards. The motor is encased in dust-proof covers, which keep the dust away from the armature and bearings. As may be seen, all the parts of the arrangement are self-contained, and neither the motor nor the counter-shaft has to be fastened to the wall. The plain cutter and reamer grinders are furnished in the same way, but since a revolving work spindle is not used for these, the counter-shaft is done away with, the spindle being driven directly from the armature shaft.

SPRINGFIELD MOTOR-DRIVEN BRASS FINISHERS' LATHE.

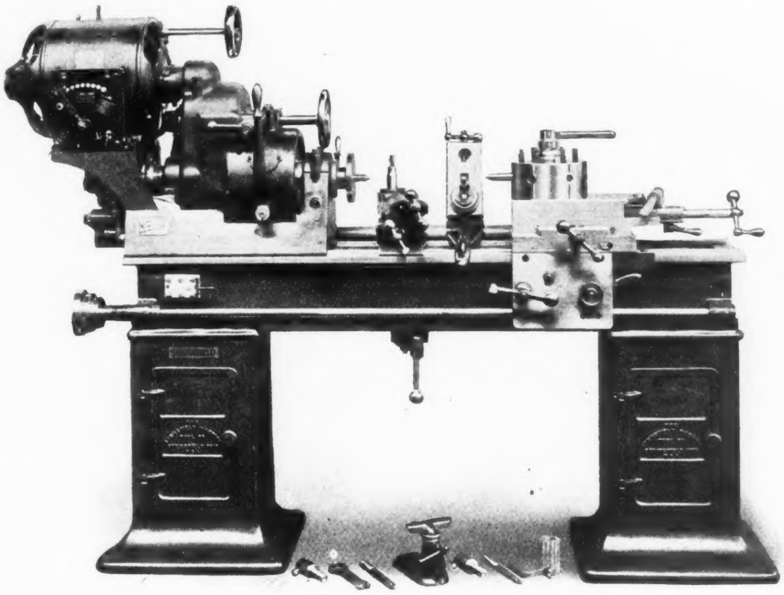
The half-tone engraving shown herewith illustrates quite clearly the motor drive mechanism provided by the Springfield Machine Tool Company, 633 Southern Avenue, Springfield, Ohio, for its brass finishing lathe.

The head-stock shown provides for four mechanical speed changes, and this, in combination with the Lincoln 6 to 1 variable speed motor with which the lathe is driven, gives the entire range of speed necessary for the work for which the machine is intended. The Lincoln motor (see description in the New Tools Department of the March, 1906, issue of MACHINERY) is provided with mechanism for shifting the armature and field longitudinally in relation to each other, so as to obtain a stronger or weaker field at the desire of the operator, thus diminishing or increasing the speed of the machine. This movement is effected by the hand-wheel shown projecting from the upper part of the motor casing. It is within convenient reach of the operator, who can thus make the changes with great ease. The starting box is placed at a convenient point, and releases automatically when the power is turned off. The motor is reversed in this case by a double throw switch on the bed at the head of the machine.

The head-stock, with its gearing, clutches, etc., is of neat and compact design, all the working parts being enclosed to protect them from injury and dust. Of the four mechanical changes of speed, two are obtained by the short lever seen just in back of the friction lever. This operates a sliding gear arrangement. Two more changes are obtained by the usual friction back gear mechanism, operated by the vertical lever. The clutches used for this friction back gear drive have been built by this firm for many years, and have given entire satisfaction. The lower hand-wheel shown just over the main spindle bearing is used for rotating the spindle for such minute adjustments as are required, for instance, in finishing a square thread, ending in a drilled hole. The journals throughout the head-stock mechanism are self-oiling, with large oil receptacles which seldom require refilling.

The turret is large and heavy, with bushed holes. It is provided with an ingenious indexing and locking mechanism operated by the handle shown at the top of the turret. The backward movement of the handle withdraws the locking pin, a forward movement rotates the turret into a new position, when the locking pin drops back into place locating the turret, and then the returning of the handle to its first position clamps the turret firmly to the carriage. Both screw and lever feed are provided for by the slide, the screw feed being used where fine adjustments are required. As is usual in brass finishing lathes, the turret is mounted on a cross slide. The cross slide is centered on the carriage by means of a taper pin, which insures absolute alignment. A taper attachment is also provided, of which the taper bar is contained in the center of the bed. It may be adjusted to any required taper up to 4 inches per foot. The slide on the bar is gibbed to take up all wear. All the ways of the turret, cross slides and carriage are fitted with taper gibs throughout.

The apron is provided with a power feed, driven by a three-



Springfield Brass Finishing Lathe, as arranged to be driven by Lincoln Variable Speed Motor.

step cone. The feed is reversed by the lever at the side of the apron, and is engaged by a friction clutch. When the power feed is not in use, the carriage may be clamped to the bed by means of the rigid clamping device shown at the right of the apron.

The chasing bar is of very heavy construction, supported by large, stiff brackets. The different pitches are obtained by using different threaded leaders and followers in the usual fashion. Provision is made in this machine for cutting either right- or left-hand threads without changing any gears. A handle at the end of the bed operates tumbler gearing, which reverses the direction of the rotation of the leader; this provision makes left-handed leaders and followers unnecessary. Taper threads may be chased with this tool by tilting the slide on which the forward part of the chasing bar rests, when it is in working position. A heavy spring keeps the follower in contact with the leader, thus assuring uniformity of lead to the thread being cut.

* * *

Few people realize what a tremendous industry the moving picture industry has become in a few years. One of the French companies, manufacturing the films for moving picture machines has a capital of $900,000, and in 1906, according to an item in *Industritidningen Norden*, the net profit from this investment amounted to fully one million dollars. In 1907 the sales were nearly twice the sales in 1906. It is stated that the company sells about 19 miles of films a day, and that they keep continually in stock 30 tons of films, representing a value of $1,400,000. It is also stated that all the moving picture enterprises in Paris represent a capital of over $20,000,000, and that there are fully as many English and American firms in this industry as there are French.

AN AMERICAN MECHANIC IN EUROPE—1.

THE FIRST OF A SERIES OF LETTERS FROM OSKAR KYLIN* ON THE EDITORIAL STAFF OF MACHINERY.

Berlin, March 14, 1908.

The industrial depression which last fall started in New York and with that as a center spread over Europe, seems to have affected the machine tool market here to quite a large extent. Machinery dealers report business very dull throughout the country, the machines that they ordered from American manufacturers six months or more ago are now coming in, and as the demand is small at the present time, they are obliged to store them. The depression is most evident in the line of large machine tools. Smaller machine tools for every day uses are in fair demand, and in small tools, business is still better. Schuchardt & Schutte report a falling off of about 50 per cent of last year's business in all kinds of machine tools and small tools.

The machine tool manufacturers here do not seem as yet to feel the depression in any marked degree. They are generally running their shops with nearly full force, and do not complain about any hard times. Ludwig Loewe & Co. reported a fair amount of business on hand, working with very nearly full force. A small manufacturer here that six months ago employed 125 workmen has now reduced his force to about 90 men, but he stated that business was unusually good then, is satisfied with present conditions, and is optimistic about the future. This marked difference between the reports of dealers and manufacturers probably results from the fact that manufacturers are still working on orders received six months or more ago.

Copying American Tools.

I have carefully investigated the copying of American machine tools abroad, and the German manufacturers no longer seem to make any secret of this practice. They openly confess that they do copy American machines, or rather that they imitate them and adapt them to the different requirements that exist in the German shops. Outright copying does not seem to be so common as imitation or rather adaptation.

There seems to be some difference between the structure of the German cast iron and the American, and the small tools designed to suit American conditions and material cannot be used with equal advantage here, as they are too light and do not wear well. The German manufacturers have studied their material and tools, and the consequence is that today a different line of tools is used here from those in America. It is a common complaint that most American manufacturers who are selling machines here do not pay enough attention to this point, and that the American machines are not made to take the German tools. The feeling is that if American manufacturers want to sell machines here they should study the German needs and adapt the machines to meet them; and since this is not being done, the German manufacturers will naturally adapt the latest and best American tools to their own requirements, retaining the new features when they conform to German needs and changing them when they do not. American manufacturers, by neglecting to study the needs here are to a certain extent responsible for present conditions; and it must not be forgotten that this does not apply to the trade in Germany alone, but to all the territory where German tools are sold, which includes all Europe and Asia. Whether justly or not the dealers here continue under the impression that during the past boom American manufacturers did not treat their foreign customers fairly, neglecting them in favor of domestic orders,

* Oskar Kylin is a young American draftsman who is making a trip through Europe for MACHINERY, and recording his impressions of foreign methods and works from the standpoint of a practical mechanic. In addition to having a thorough knowledge of American shop practice, Mr. Kylin speaks several languages fluently.

and for this reason have lost ground on the foreign market, a condition which German manufacturers have been quick to profit by.

An Interesting Interview.

An interview with Mr. C. H. Johnson, who has represented the Gisholt Machine Co. on the Continent for a number of years, is given below, as it is fairly typical of opinions here, and taken from an intelligent standpoint, as Mr. Johnson is an American. "Write the American machine tool manufacturers that more of them should begin to study the needs and conditions here, which are not the same as they are over in America. They build machines there to suit American conditions and American material, and don't think or care about the conditions or material here. Then they send their machines over and want us poor devils to sell them. There are some American concerns that know how to handle European trade, but they are very few. America mustn't think that Europe is in its mechanical baby clothes any longer, or conditions are any longer such that when the American business managers come over, buyers here salute them with 'How d' you do? Glad to see you! I am just ready to buy your machines.' Things have changed. The Germans build pretty good machines themselves now, and the material is not the same here as in America. The cast iron, for instance, that we have here is very much harder or tougher, for the tools don't wear so well here and get dull much faster, so that we can't use the American tools. The tool question has been studied out in both countries, and now they do it one way in America and another way here. We cannot force the Germans to use our tools, and we must make our machines to suit their tools if we want their trade. There are some good American concerns that do so, but the large majority don't. The American business manager goes over to Europe to make a thorough study of the European trade conditions—makes a hurried call in Berlin, and then takes the fastest express for Paris, and that is where he studies 'trade conditions.' And now since the Americans won't make their machines to suit the German tools, the Germans must do it themselves. They simply have to; and you can take my word that they do it, too. The Germans are d— good copiers. They copy lots of American machines and adapt them to their own tools, and what can we do about it? Not a d— thing! They must use their own tools, and the American manufacturer won't make his machines to suit the German tools—so there you are. And it is not so very easy to sell a machine here as in America either. I sold a milling machine here the other day, and when it came, the customer picked up and took apart every piece—in order to clean it, he said, but really to examine it. He looked at every piece, and if he had found any defects he would have refused the machine. And suppose now that I want to sell a lathe. I have to sell it against the competition of a 25 to 50 per cent cheaper German one. If I say that my lathe is equal to two or three German lathes I must get down to figures and show the buyer why. My lathe won't do two or three times as much work as the other one, and therefore I have to figure on the floor space. Three lathes will occupy so much space and mine only so much, and this represents a saving of so much a year for you. I have to figure with power, transmission and everything. So you see that it is not so very easy to sell American machines here.

"And then there is another point. During prosperous times the American manufacturers have neglected their foreign trade. They acted as if they thought, 'We will attend to our home customers and let the devil take the foreigners; they can wait.' And if a German customer has been promised one month's delivery he has often had to wait six. Now everybody wants to sell, but it is pretty hard work to get back the trade for American machines again, and it is the American concerns that are principally responsible for it."

Shop Notes from Ludwig Loewe & Co.'s Shops.

In Ludwig Loewe & Co.'s Works there is a tendency to abandon the milling operation for finishing heavy castings, such as large bed-plates. They are going back to the old way of planing these castings, which they claim costs less, because the milling cutters wear too fast and are too expensive both as to first cost and maintenance. This may be on account of the difference in the wear on German cast iron.

An interesting experiment was tried in these works for forming a milling cutter that would cut a perfectly square thread in the ordinary thread milling machine. As generally known, the "square" thread cut in an ordinarily equipped thread milling machine, although close enough for most ordinary purposes, is not perfectly square but somewhat wedge-shaped. An ordinary Pratt & Whitney thread milling machine was used, a square thread screw, cut in a lathe, being placed in position the same as for milling a thread. In the place of the cutter an antimony disk was mounted on the cutter spindle. The screw was revolved and the antimony "cutter" pressed against it and caused to revolve with it. By this action the disk was formed to the right shape. A steel cutter was made to the shape thus produced, but as it did not work well, the experiment was carried on to find another shape that would cut more satisfactorily. The experiment was made on account of an inquiry from the German government.

[The experiments, if conducted as described, seem quite unprofitable. No one-piece rotary cutter of appreciable diameter can be formed which will not interfere with the overhang of a square thread.—Editor.]

MISCELLANEOUS FOREIGN NOTES.

Projected Russian Steel Trust.—It is stated by *Engineering* that a Russian steel trust is about to be formed and that the promoters of the scheme desire to create a concern along the same lines as the United States Steel Corporation. The present unions between steel makers and the trade agreements are understood to have proved unsatisfactory and inefficient, but definite action has not, as yet, been taken.

Profits in German Machine Tool Trade.—A number of the principal German machinery manufacturing concerns have issued their financial statements for the last accounting year, and it is plainly in evidence that up to the present time the business has financially been an exceedingly good one. Thus, some of the large companies report net profits from $200,000 up to $800,000, and the paying of dividends varying from 12 per cent to 20 per cent as against from 8 per cent to 16 per cent in the previous year. It is now stated that the prospects for the German machinery trade, while not as bright as they have been, are still fully satisfactory.

Messrs. A. A. Jones, Pollard, and Shipman, Ltd., Leicester, England, have placed a new design of high speed drilling and tapping machine on the market. This machine is of stiffer construction than usual, and is particularly intended for using high speed drills up to their full capacity. The machine will drill one inch holes in mild steel at a rate of three inches per minute. The machine is back-geared and the main drive is by a three-inch belt. Instead of the common feed lever, a hand-wheel is employed. The drill spindle is bored to take No. 3 Morse taper shank. It has a vertical travel of 10 inches. The table is 17 inches in diameter. The maximum distance between the drill spindle and the table is 33 inches.

British Shipbuilding Trade.—We have previously referred to the fact that the British shipbuilding concerns were not fully satisfied with the prospects in their trade. Present orders, it is stated, are practically confined to high-class steamers, and for these there is a very keen competition. Of course, the building of large vessels in the last few years has been carried to such an extent that naturally the number necessary for the immediate demands of the trade is filled for the present. The probable state of affairs is that the activities of the past few years have been abnormally high, and that business now recedes temporarily only to enter on thoroughly healthy and normal conditions.

Steel Industries in Europe.—It appears that while the steel industry in certain of the European countries is rather depressed, there is still considerable activity in the development of new plants. A large iron works is under construction in Italy near Naples, for which six blast furnaces and large rolling mills will be erected. From France a depression is reported, although not as accentuated as elsewhere. The exports of iron and steel in that country still show an increase over the exports for the corresponding months last year. In

Germany the steel syndicate has decided to make no change in prices, and it is reported that the export trade shows signs of improvement. To a great extent the works are now kept busy with materials for the German Government railroads.

GERMAN COMPETITIVE RESTRICTION.—Consul-General Richard Guenther mentions in a consular report the following incident, illustrating the restrictive law in Germany covering unfair competition. An Austrian merchant was recently convicted in the criminal court at Konstanz, Germany, of having violated the law against illicit competition. He was sentenced to imprisonment for three months. This foreign merchant, who intended to establish in Austria a factory for preserving vegetables, had come to Singen and approached the employe of a similar factory there, trying to induce him to reveal the business methods, technical appliances, and manner of production in vogue in the establishment; also where the supplies in raw materials were obtained and the names of the customers of the factory. He offered money gratuities to the employe, who was a sort of foreman, and promised him a better-paying position in his factory in Austria. Some of our American manufacturers, says the Consul, are very enterprising and occasionally—when in Europe—seek to obtain information by personal efforts. The case cited may be useful in cautioning personal investigators to be very circumspect, so as not to violate existing laws in foreign countries.

SALES OF MACHINERY IN ITALY.—According to the *London Commercial Intelligence*, protection as to payment for machinery sold to Italian firms may, according to Italian commercial law, be secured, if the sale, within three months from date of invoice, is registered at the chancery of the civil and penal tribunal of the city where the machinery is to be installed. This registration offers protection for the final payment of machinery. In order to secure this privilege of protection, it is necessary for the seller to send in an application addressed to the "Regia Cancelleria del Tribunale Civile e Penale, Sezione Commerciale" of the city or town where the machinery is delivered, stating details regarding price, terms of payment, etc. This application is made out in duplicate on Italian stamped paper, one copy being returned by the tribunal after registration. The expense for the stamped paper is about 70 cents. The application should also be accompanied by the contract for the sale of the machinery, or by a copy of the invoice. The copies must be stamped and registered with the Italian government at a representative office (undoubtedly the Italian Consular office would in the United States be the proper place). An amount sufficient to cover postage for the return of the duplicate application should be enclosed.

* * *

ANGLES OF HOPPER SIDE INTERSECTIONS.

The perplexing problem of finding the angle of intersection between the various inclined planes in a rectangular hopper has been previously dealt with in the columns of MACHINERY, in the "How and Why" section of the May, 1907, issue and in the "Letters Upon Practical Subjects" section in the August, 1907, issue. In these articles general formulas were given, which, however, are more or less complicated and require considerable time in applying to each separate case. In the current Data Sheet Supplement, accompanying the engineering edition, diagrams are therefore presented which permit the required angle of intersection to be read off at a glance, when the inclinations of the side planes of the hopper are known.

In sheet metal work of this character it is common to express the magnitude of angles by giving the inclination in inches per foot; in inches rather than by expressing the angles in degrees. This practice has been adhered to in arranging the diagrams given. The curves, however, have been plotted from the formula

$$\operatorname{Cos} F = -\cos x \cos y,$$

in which the various angles are expressed in degrees, and where F = the angle of intersection between the sides of the hopper (commonly called the angle of flare), x = the angle which one of the hopper sides makes with a plane parallel to the bottom of the hopper (or with a horizontal plane), and y = the angle which the other hopper side makes with the same plane. Upon examination it will be found that the formula given above is identical with the one given in the article in the August issue, already referred to. This formula in that issue, however, was given the form

$$\cos EBF = -\sin \alpha \sin \beta,$$

where angle EBF = the angle of flare, and α and β, the angles made by the hopper sides with a vertical plane passed down the hopper at right angles to the plane in relation to which angles x and y are measured. The angles α and β thus are the complements of angles x and y, and consequently

$$\sin \alpha \sin \beta = \cos x \cos y,$$

from which it is clear that the two formulas referred to are identical.

* * *

PERSONAL.

Charles C. Tyler, lately of the Allis-Chalmers Co., has been appointed works manager of the Remington Arms Co., Ilion, N. Y.

George A. Seib, formerly superintendent of the Monarch Typewriter Factory, Syracuse, N. Y., has been appointed superintendent of the Remington Typewriter Co.'s factory, Ilion, N. Y.

J. L. Cone, for several years foreman of the carriage assembling department of the Remington Typewriter Co., Ilion, N. Y., has been appointed assistant superintendent of the machine assembling department.

David Hunt, Jr., general sales manager of the Warner & Swasey Co., Cleveland, Ohio, sailed February 29 for a three months' trip abroad. He will visit England and the Continent.

John Montgomery formerly foreman of the screw department has been appointed assistant superintendent of the machine tool and equipment departments of the Remington Typewriter Co., Ilion, N. Y.

T. D. W. Moore, for three years general manager of the Remington Arms Co., Ilion, N. Y., has accepted the position of general manager of the Savage Arms Co.'s plant at Utica, N. Y. Mr. W. J. Greene retires as general manager of the Savage Arms Co., but still continues as vice-president.

R. S. Stangland has been placed in charge of Muralt & Co.'s construction office at New Fort Lyon, Colorado, and will superintend the erection of the complete lighting, heating and power plant which his firm is building for the United States government at the New Fort Lyon Naval Hospital.

Jerome Orcutt, who for several weeks has been acting as general manager and superintendent of the Remington Arms Company's plant, Ilion, N. Y., in connection with the management of the Union Metallic Cartridge Co.'s plant at Bridgeport, Conn., has returned to Bridgeport, and will confine himself to the management of the Union Metallic Cartridge Co.

W. O. Renkin, formerly of Valley Park, Mo., and an occasional contributor to MACHINERY, is now located at Chakradharpen, India, as resident engineer for Julian Kennedy, construction engineer, Pittsburg, Pa., for the erection of blast furnaces and steel works for the Tata Iron & Steel Co. Mr. Renkin expects to be in India at least three years.

The well-known inventor of the Schmidt superheater, Mr. Wilhelm Schmidt, of Kassel-Wilhelmshöhe, Germany, has been promoted to Honorary Dr. Engineer of the Technical Institution of Karlsruhe, "in appreciation of his services for making use of superheated steam in steam engines, particularly in locomotives, and for his initiative efforts in the construction of apparatus and superheaters for highly superheated steam."

Anton M. Olsen, an apprentice of Kempsmith Mfg. Co., Milwaukee, Wis., has the distinction of being the first apprentice west of New England to receive the diploma awarded by the National Machine Tool Builders' Association. Mr. Olsen signed the National Machine Tool Builders' uniform apprentice contract May 25, 1904, at the age of sixteen. The apprentice service required is 11,520 hours divided in four general annual periods of 2,880 hours each. Mr. Olsen completed this term in the early part of March, and received his diploma.

OBITUARY.

George P. Curtis, who for the past twelve years was connected with the city sales department of Charles H. Besly & Co., Chicago, died February 26.

John Burry, inventor of a stock ticker in common use in brokers' offices, hotels, clubs, etc., for recording stock market quotations, died at his home on Staten Island, March 12, of illuminating gas poisoning. Mr. Burry was born in Switzerland in 1861, and came to the United States at the age of nineteen. He had made many inventions and improvements of printing telegraph machines. The stock ticker, brought out in 1880, was the most successful.

George J. Meyer, treasurer of the National Tool Co., Cleveland, Ohio, died at his home, 2003 Holmden Ave., February 23, of consumption. Mr. Meyer was one of the incorporators of the National Tool Co., and held the position of treasurer from its incorporation until his death. He was previously employed by the Dyer Co., Cleveland, as a draftsman and machine designer, and thus was a practical machine designer as well as a business man. Mr. Meyer was highly regarded by his associates, and his untimely death leaves a place hard to fill. He left a widow and two children.

James H. Oliver, a well-known plow manufacturer of South Bend, Ind., died March 2. He was born in Roxburgh, Scotland, August 28, 1823, and came to the United States with his family when a lad of thirteen, settling near Geneva, N. Y. After working on a farm for a few years, he went to Indiana and became a mill worker, and after accumulating a small sum, began to make plows. The problem of making a cast iron plow that would scour in the black Western soils was what he set out to solve, and the Oliver chilled plow was the result. The demand increased so rapidly that in 1875 the present plant at South Bend was built, covering thirty-two acres and employing 5,000 men.

* * *

NEW BOOKS AND PAMPHLETS.

PROCEEDINGS OF THE SEVENTEENTH ANNUAL CONVENTION OF THE ASSOCIATION OF RAILWAY SUPERINTENDENTS OF BRIDGES AND BUILDINGS, held in Milwaukee, Wis., October 15-17, 1907. 344 pages, 6x9 inches. S. F. Patterson, secretary Boston & Maine Railroad, Concord, N. H.

COLUMBIA UNIVERSITY QUARTERLY. December, 1907. 141 pages, 7x10 inches. Published by Columbia University, New York.
This issue of the *Columbia University Quarterly* is devoted to the Columbia Schools of Mines, Engineering and Chemistry, and will be found of general interest to those contemplating courses in these well-known institutions.

THE WEATHERING OF COAL. By S. W. Parr and N. R. Hamilton. 37 pages, 6x9 inches. Published by the University of Illinois, Urbana, Ill., for general distribution.
The bulletin relates to the weathering of coal and losses in fuel values which result from storage. That coal deteriorates in storage is generally known, but the data available have been meager. The results of tests outlined give specific information that should be valuable to manufacturers, power plants, and others using large quantities of fuel.

EFFECT OF BRAKE BEAM HANGING ON BRAKE EFFICIENCY. By R. A. Parke. 63 pages, 6 x 9 inches. Published by the Westinghouse Air Brake Co., Pittsburg, Pa.
This publication is a reprint of a paper presented by Mr. Parke before the New York Railroad Club, April 18, 1897. It is a clear and comprehensive analytical discussion of the complicated conditions involved in the design of car brake systems of maximum efficiency, and in a way has become a classic that is often referred to for analysis of the complicated forces entering into car braking and brake action. Those familiar with the paper will be pleased to note that it has now been put in shape for general circulation, and it can be recommended to those interested in the design and mathematical analysis of railway car brakes.

LOCOMOTIVE CATECHISM. By Robert Grimshaw. 817 pages, 5x7 inches. Published by Norman W. Henley & Son, 132 Nassau Street, New York. Price, $2.50.
This work, first published in 1893, has had a large sale, the present edition being the 27th. It has been entirely revised, enlarged and reset, and contains over 3,000 questions and answers. It is, in fact, a practical treatise on locomotive construction in detail and a treatise on locomotive operation as well. The catechism style enables a great deal of information to be given in short, concise paragraphs, and is well suited to the needs of men who are not used to reading technical books. The work is one, also that can be read with profit by any one who desires to obtain general information on locomotive construction and operation. The illustrations are well made, the paper is of good quality, the binding is flexible, and the corners are rounded, which adapt the book to carrying in the pocket, although its size is somewhat too great to make it a comfortable pocketbook.

REFERENCE BOOK FOR STATICAL CALCULATIONS. Vol. I. By Francis Ruff. 136 pages, 5x7½ inches. Published by Spon & Chamberlain, New York. Price 5d.
This book was first published in German and to meet the wants of English engineers has been translated into English. The work presents the application of grapho-statics to the constructions most frequently met in engineering work. It contains tables of moments of inertia and resistance to bending on cross sections most in use, and transverse forces and moments of applications for simple beams subjected to concentrated loads and distributed loads. Bridge trusses, strut frames, roof construction, cantilevers, open web girders are analyzed graphically; also curved beams with three joints, suspension bridges, frame work columns, earth pressure, sustaining walls, vaults with abutments, concrete constructions. The work will be found useful by all who have occasion to analyze the forces in engineering structures. The tables are conveniently arranged and data not usually found in engineering handbooks are included.

ENGINEERING REMINISCENCES. By Chas. T. Porter. 335 pages, 6x9 inches. Illustrated with portraits of many prominent engineers. Published by John Wiley & Sons, New York. Price, $3.00.
This work first appeared as a series in *Power* and the *American Machinist*. Mr. Porter was the originator of the high-speed engine, and has had a most interesting career. His writings have a charm and interest rarely exceeded by any. The book is a contribution to engineering literature of much historical value, and it is a matter for general congratulation that the memoirs of a man who has done so much for engineering should be put into a book for general circulation. Electrical engineering owes much to the Porter-Allen engine, as incandescent lighting would have been impracticable with the old slow-moving, irregular-acting steam engines in use prior to Mr. Porter's development. So in a sense it may be said that Mr. Porter is very largely responsible for the enormous development of electrical engineering that has taken place since the first high-speed engine was constructed.

THE GAS ENGINE. By Frederick R. Hutton. 562 pages, 6 x 9 inches. 243 illustrations. Published by John Wiley & Sons. Price $5.00.
The first edition of Prof. Hutton's work on the gas engine was published in 1903. The present edition is the third, revised and brought up to date. The development of the internal combustion motor and the importance that it has acquired since the introduction of the automobile makes the study of the gas engine and gas fuels of the greatest commercial importance. The new edition has been revised with this fact in view and special attention is called to the reference table on gaseous fuels now included. Some attention is given to alcohol motors, but the treatment of the design of engine parts included in previous editions has been intentionally omitted, it being thought best not to include this, as it would make the work too large and costly. For design and construction details the author calls attention to the work "Gas Engine Design," by Prof. Charles E. Lucke, who is a colleague and co-worker in Columbia University. Prof. Hutton's work is generally considered to be the most comprehensive theoretical treatment of the gas engine published in America.

GAGES AND GAGING SYSTEMS. By Joseph V. Woodworth. 249 pages, 6 x 9 inches. 258 figure numbers. Published by the Hill Publishing Co., New York. Price, $2.00.
This book on gages and gaging systems is a compilation of articles published in the *American Machinist* and MACHINERY, contributed by the author and others. It treats of the fundamental practice, development and efficiency of gages and gage making with numerous illustrations of various forms of limit gages, indicators, thread testing gages, snap gages, star gages, caliper gages, etc. A chapter is devoted to tri-squares, knife edge squares, combination squares, straight-edges, sizing blocks and methods of making same. Special attention is given to calipering large work and the methods developed and employed by the Westinghouse Co. are partially described. Simple methods of testing the alignment of machine tools with the ordinary micrometer are illustrated. The Gronkvist or Swedish combination gage system is illustrated, this being a new system by which less than 100 gages are made to have about 80,000 combinations. The work is one that should be useful to tool-makers, gage-makers, machinists, etc.

PRACTICAL STEAM AND HOT WATER HEATING AND VENTILATION. By Alfred G. King. 402 pages, 6 x 9 inches. 302 illustrations. Published by Norman W. Henley & Son, 132 Nassau St., New York. Price, $3.00.
The work reviews modern methods of steam and hot water heating and ventilation, and describes the apparatuses. It treats of the nature of heat, and the evolution of artificial heating apparatus from the open fire-place to stoves, furnaces, steam boilers, and hot water systems. The work is comprehensive and useful. It gives rules for estimating, and tables of value to engineers, estimators and others having charge of the installation of heating systems. The work as a whole appears commendable and we see little in it to criticise adversely, except in one chapter given up to rules, tables and general information. Some of the statements contained are puzzling, as for example: "Air expands one one hundred and seventy-ninth of its bulk." This of course means nothing at all without an explanatory statement. A typographical error makes the rule for finding the diameter of a circle when the circumference is given, to read "Divide the circumferencee by 4.14159," instead of 3.14159. The general arrangement of the work is good and with few exceptions the illustrations are first class. The tables are gotten up in exceptionally fine style.

HANDBOOK FOR THE CARE AND OPERATION OF NAVAL MACHINERY. By H. C. Dinger. 302 pages, 4½x6 inches. Published by D. Van Nostrand Co., 23 Murray Street, New York. Price, $2.00.
The larger part of this series first appeared as a series in the *Journal of the American Society of Naval Engineers*, and has been reprinted in book form with modifications and numerous additions. It is a practical treatise on marine boilers and engines, fittings, auxiliaries, with instructions on the care and preservation of the ship's hull, water-tight compartments, etc. Following are some of the subjects treated which will give a general idea of the contents of the work: Getting under way; running engines under way; accidents under way; general rules for over-hauling machinery; cylinders, valves and valve gears; engine adjustments; lining up engines; friction, oiling and lubrication; condensers and pumps; joints and packing; stuffing boxes; lagging; feed and filter tanks; feed-water heaters; evaporators and distillers; heating system; refrigerating plant; steam steering gear; air compressors, blowers and boiler engines; ash hoists and ejectors, etc. The work is one that can be heartily recommended to any one desiring an elementary, yet comprehensive work on marine machinery. It is gotten up in durable shape and is of convenient size to carry in the pocket.

WRITING FOR THE PRESS. By Robert Luce. 302 pages, 5 x 7 inches. Published by the Clipping Bureau Press, Boston, Mass. Price $1.00.
This book, first published in 1886, now appears in the 5th edition. It is deservedly popular, and will be found of general value to all who write for publication or who indite business letters, or in any way express themselves in written language. The instructions to writers for the press are practical and concise and, with one exception, meet our general approval. The exception is in the directions for the preparation of copy containing illustrations. It states that the proof of any cut to be used in illustrating an article should be pasted as near as possible to the proper place in the copy. This is not objectionable when the proof is *not to be used as copy* for making the cuts but in all cases where the illustrations are copies for new cuts they should be separated from the manuscript and numbered or marked in such a way as will distinguish them. This saves the manuscript-revisers the trouble of cutting out the illustrations, which will be necessary if they are a part of the manuscript. The book contains lists of common expressions with superfluous words and much other matter that characterizes bad English. A great deal of practical information regarding the business of printing and publishing is included. We would recommend the book to our readers in general, especially those who have the making up of advertising pamphlets, catalogues, brochures, etc.

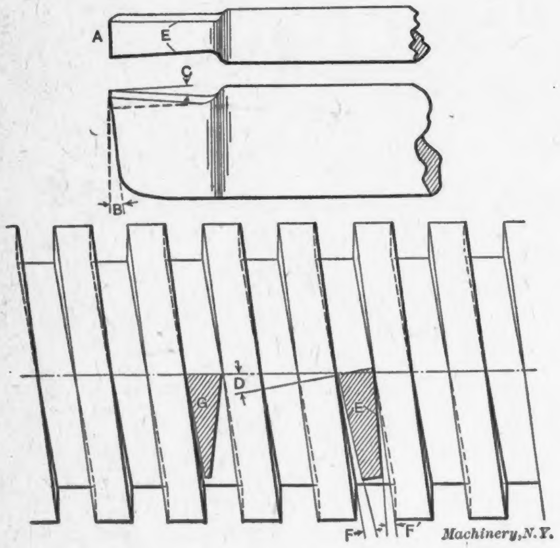
CUT OUT ON THIS LINE.

CUT OUT ON THIS LINE.

PUNCH PUNCH

SHOP OPERATION SHEET NO. 58.

E. H. Fish. MACHINERY, April, 1908.



To Grind a Thread Tool for Cutting a Square Thread.

1. Grind the nose *A* of the tool square across the end, and wide enough to be a tight fit between the teeth of the tap which the thread is to follow. If a tap is not used, make the width of the nose equal to one-half the pitch of the thread to be cut. If a close fit is required, the width of the nose may be made 0.002 or 0.003 inch less, and the thread finished to size by taking light cuts from the side of the thread.

2. Grind the front face of the tool until the angle *B*, of front rake, equals 5 to 8 degrees.

3. If the thread is to be cut in soft steel, grind the top of the tool until the angle *C*, of top front rake, equals from 5 to 10 degrees; if cast iron is to be cut, there should be very little top front rake, and when cutting brass the top front rake is often negative, as shown by the dotted line, varying from 0 to 5 degrees. The top of a thread tool should also be ground to an angle *D*, sufficient to make the top at right angles to the sides of the thread.

4. Grind the sides *E* so that they have a backward taper of from 1 to 3 degrees on each side, and a downward taper of from 3 to 5 degrees on each side. This downward taper is indicated by the angles *F* and *F'*. Note that the angle *F* is the angle between the side of the tool and the side of the thread at the bottom, while the angle *F'* is the angle between the side of the tool and the side of the thread at the top.

NOTE.—If the tool is ground as shown at *G*, it will rub on the left-hand side as the cutting of the thread progresses, and be gradually crowded to the right, impairing the accuracy of the thread.

PUNCH PUNCH

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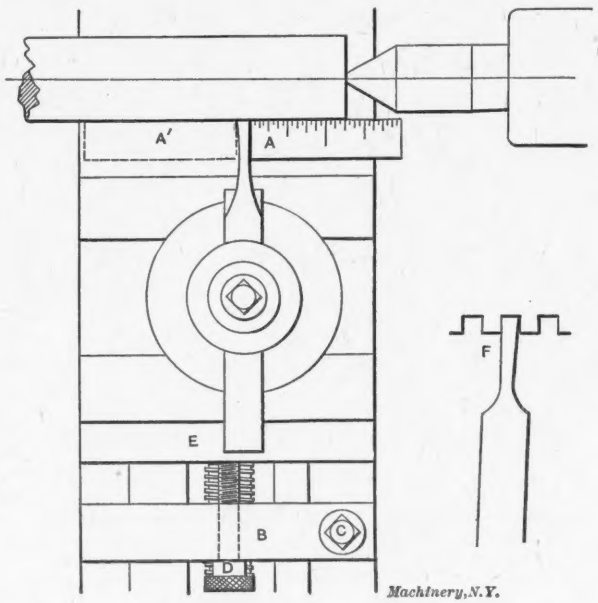
SHOP OPERATION SHEET NO. 59.

E. H. Fish. MACHINERY, April, 1908.



To Cut a Short Right-hand Square Thread.

1. Center and turn the blank, making its diameter from 0.002 to 0.005 inch less than the diameter of the tap.

2. Gear the lathe so that it will cut a thread of the required pitch. See Shop Operation Sheets Nos. 13, 14, 15, in September, 1907, issue of MACHINERY.

3. Set the tool so that its cutting edge is the same height as the lathe centers, and set it square with the work by using a scale as shown at *A* and *A'*.

4. Place the tool against the work, and fasten the depth gage *B* to the carriage by a bolt *C*. Screw the screw *D* into the tool-slide *E* until its shoulder is against *B*.

5. Loosen the screw *D* sufficiently to give the tool the proper depth of cut, move the tool to the right-hand end of the work, and start the lathe. Feed the tool inward until the shoulder on *D* is against *B*, and then engage the split nut with the lead-screw of the lathe, and take the first cut. When the tool has cut as far as desired, reverse the lathe and withdraw the tool at the same time. Again unscrew the screw *D* slightly, and when the tool has reached the right-hand end of the work, again reverse the lathe and feed the tool inward as before. Continue in this manner until the diameter at the root of the thread is from 0.002 to 0.005 inch less than the same dimension on the tap.

NOTE.—If the thread, when cut, is too tight a fit, it may be due to the tool having been ground too narrow, or to the pitch of the tap having changed in hardening. In such a case, the tool may be set as shown at *F*, and light cuts taken from the sides of the thread until the required fit is obtained.

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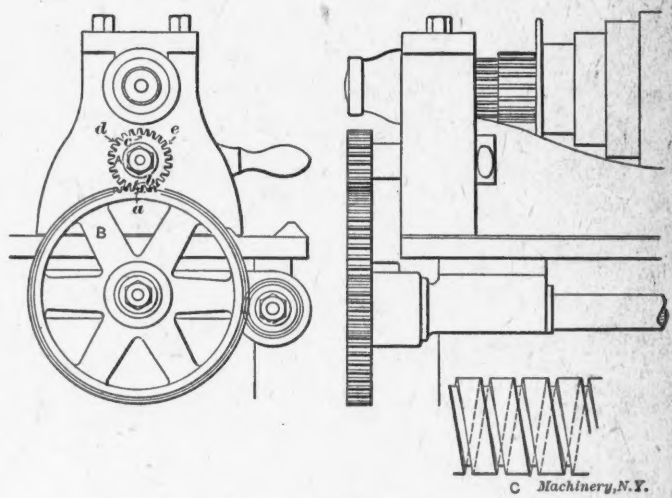
SHOP OPERATION SHEET NO. 60.

E. H. Fish. MACHINERY, April, 1908.



To Cut Double and Triple Threads.

1. To cut a double thread, gear the lathe so that it will cut a thread of the required lead, (the lead of a double thread equals twice the pitch) selecting a change gear *A* which has an even number of teeth. Mark a tooth *a* on the intermediate gear *B*, and a space *b* on the gear *A*. Half-way around gear *A* mark a space *c*.

2. Cut a thread on the blank, proceeding the same as if a single thread were being cut. After this first part of the thread is finished, the blank will appear as shown at *C*.

3. To finish the double thread, a second cut must be taken midway between the turns of the first cut. Turn the lathe until the tooth *a* is in mesh with the space *b*, and then disengage the gear *B* from *A*. Again turn the lathe until the tooth *a* will mesh with the space *c*, and then clamp the gear *B* in place. Cut the second part of the thread to the required depth. The tool should not be disturbed during this operation, and it is especially important that the tool be carefully ground so that it will not crowded sideways.

1. To cut a triple thread, gear the lathe so that it will cut a thread of the required lead, (the lead of a triple thread equals three times the pitch) selecting a change gear *A* with a number of teeth which is divisible by three. Mark the spaces *b*, *d*, and *e*, dividing the gear into thirds.

2. Cut the first thread to the required depth.

3. Disengage the gear *B* from *A*, and turn the spindle until tooth *a* meshes with space *e*, then cut the second thread.

4. Again disengage the gear *B* from *A*, and bring the space *d* into mesh with tooth *a*, then cut the last thread.

NOTE.—This method of cutting multiple threads applies only when the stud on which the gear *A* is mounted and the lathe spindle have the same speeds. On some lathes the spindle makes two revolutions to one of the stud. In such a case the divisions on the gear *A* can be made on one-half of the gear.

MACHINERY'S DA

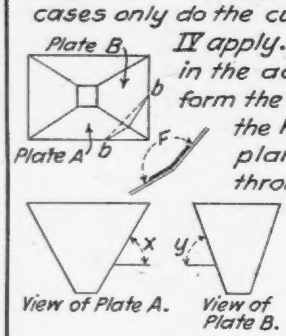
Contributions and data suitable for publication in these Data Sheets are

PUNCH O

PUNCH O

I.—ANGLES OF HOPPER SIDE INTERSECTIONS.

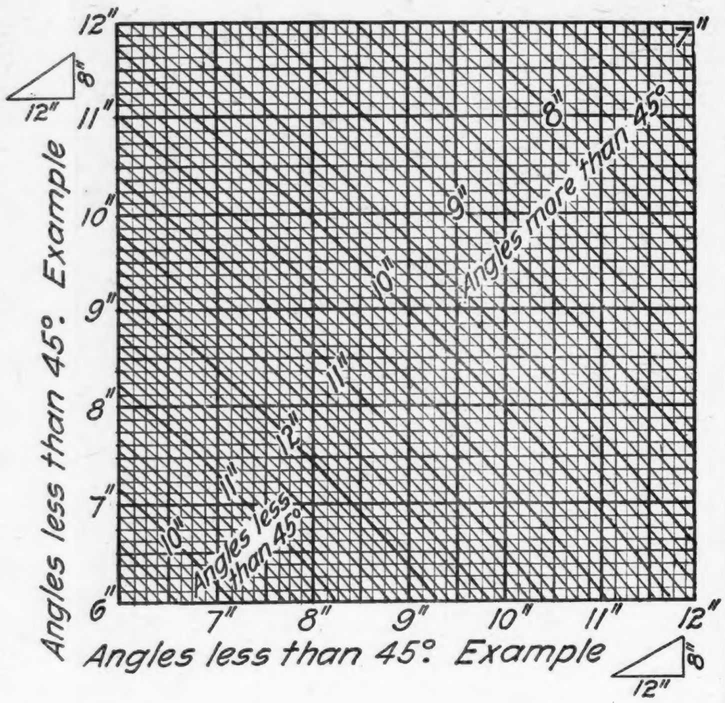
Usually there may be passed through an ordinary hopper or chute, a plane which will cut out a section having four straight sides and four right angles, and to these cases only do the curves on sheets I, III and IV apply. Let plates A and B in the accompanying sketch form the angles x and y with the horizontal plane. If a plane b-b be passed through perpendicular to their line of intersection, and the angle of flare be called F, then cos F = − cos x cos y. The curves were calculated from this formula.



The values of the angle of flare and the angles formed by the hopper sides are expressed in the slope of inches per foot.

The angle of flare is expressed thus (12″, 8″) *if the angle is more than 45 degrees.*

The angle of flare is expressed thus (8″, 12″) *if the angle is less than 45 degrees.*



Three sets of curves are given for the three cases found in actual practise:

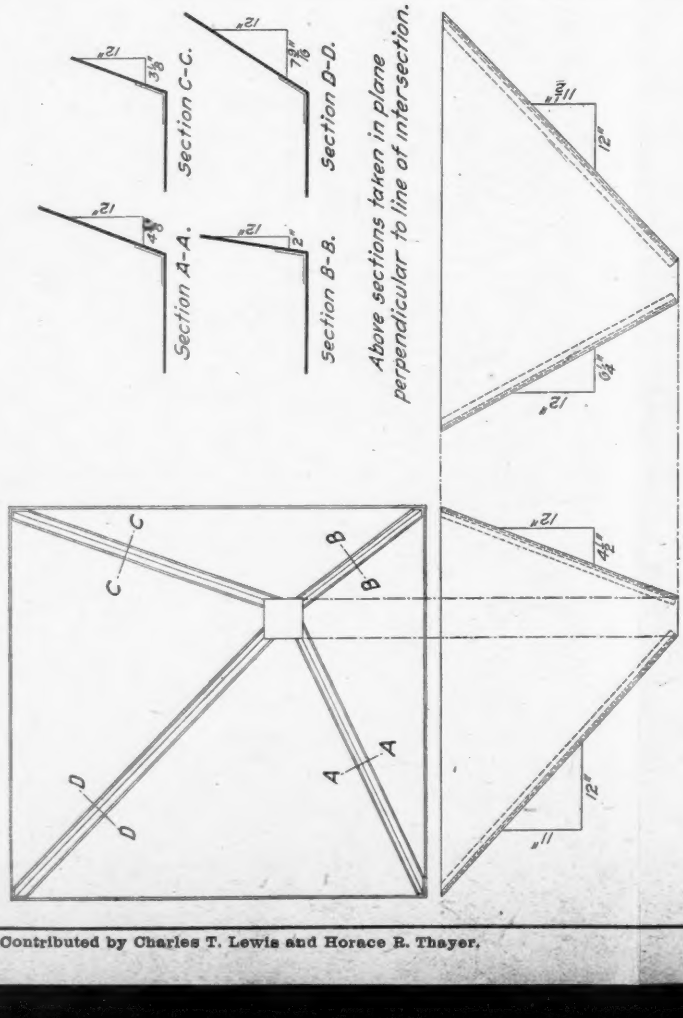
1. *Two angles, x and y, both more than 45 degrees.*
2. *Two angles, x and y, both less than 45 degrees.*
3. *Two angles, x and y, one angle less, and one angle more than 45 degrees.*

Contributed by Charles T. Lewis and Horace R Thayer.

PUNCH O

PUNCH O

II.—ANGLES OF HOPPER SIDE INTERSECTIONS.



Above sections taken in plane perpendicular to line of intersection.

Directions for the use of the diagrams.

In the accompanying illustration of hopper, let the slopes of the four sides be known, as indicated by the slope in inches per foot. For the intersection angle of the side sloping 11 inches in 12 inches with the side sloping 12 inches in $6\frac{1}{4}$ inches, use diagram for one angle more than 45 degrees and one angle less than 45 degrees. (See upper diagram, sheets III and IV.) At the left of the diagram are values ranging from 6 inches to 12 inches for angles less than 45 degrees. Follow the horizontal line at 11 inches until it meets the vertical line projected up from $6\frac{1}{4}$ inches. The intersection of these two lines gives, on the curves across the diagrams, the nearest value for the intersection angle, which in this case is $4\frac{3}{8}$ inches in 12 inches. (See section A-A of hopper on this sheet.) In a similar manner, use the diagram for two angles both more than 45 degrees (lower diagram sheets III and IV.) for section B-B, and for section D-D use diagram for two angles less than 45 degrees, sheet I.

Contributed by Charles T. Lewis and Horace R. Thayer.

This data sheet is made up so as to be readily bound. It may be cut into four sections, 6x9 inches in size, and bound into note-book form for convenient reference, by means of staples inserted into holes punched at points indicated.

CUT ON THIS DOTTED LINE AND FOLD ON *A—B*

A

B

PUNCH
O

PUNCH
O

III. and IV.—ANGLES OF HOPPER SIDE INTERSECTIONS.